U. S. ARMY ENGINEER DISTRICT, LOS ANGELES

CORPS OF ENGINEERS

L. A. METHOD

UNIT- HYDROGRAPHS

IMPROVED PROCEDURE

FOR

DETERMINING DRAINAGE AREA LAG VALUES

JULY 1962

CONTENTS

TABLE

PLATES

FOR

DETERMINING DRAINAGE AREA LAG VALUES

1. Introduction.--Synthetic unit hydrographs for drainage areas in the Los Angeles District are based on lag curves and S-graphs which were derived from rainfall-runoff relationship studies. The derivation of these curves is explained in paragraphs 70-75 of the Whittier Narrows report.* The three lag curves finally established (shown on pl. 1) were assumed applicable to three types of drainage areas: (a) mountain, (b) foothill, and (c) valley. To obtain lag values for drainage areas with characteristics representative of more than one type, it was necessary to assume a basis for prorating between these given curves. The procedure has been to determine the lag by interpolation between mountain (or foothill) and valley lag curves in accordance with the ratio of the improved channel length to the longest watercourse length in the area. It has long been recognized that this procedure has several drawbacks, most serious of which is the difficulty of according explicit consideration to side-drainage-channel and storm-drain improvements.

2. General.--To overcome the deficiencies of the procedure indicated above, consideration was given to estimating a basin factor, representing the flow characteristics, for each area pertinent to a hydrologic study. Accordingly, a basin factor ($\bar{n}$) was estimated for

* District engineer's report titled "Hydrology, San Gabriel River and the Rio Hondo Above Whittier Narrows Flood-Control Basin With Addendum on the Hydrologic Effect of Diverting Outflow From Whittier Narrows Flood Control Basin to Los Angeles River Via the Rio Hondo," dated 20 December 1944 and revised 10 July 1946 and approved by the Chief of Engineers on 12 May 1945 and 1 October 1946.

each type of drainage area represented by the three established lag curves. This basin factor was the estimated mean of the "n" values of all watercourses within a drainage area based on Manning's formula coefficient of roughness for average channels as given in table 1 of EM 1110-2-1409.

3. Estimated basin $\bar{n}$ factors and description of pertinent drainage areas.--The estimated basin $\bar{n}$ factors and the description of the three pertinent types of drainage areas are as follows:

(a) $\bar{n} = 0.05$: Drainage area is quite rugged with sharp ridges and narrow, steep canyons through which watercourses meander around sharp bends, over large boulders, and considerable debris obstruction. The ground cover, excluding small areas of rock outcrops, includes many trees and considerable underbrush. No drainage improvements exist in the area.

(b) $\bar{n} = 0.03$: Drainage area is generally rolling, with rounded ridges and moderate side slopes. Watercourses meander in fairly straight, unimproved channels with some boulders and lodged debris. Ground cover includes scattered brush and grasses. No channel improvements exist in the area.

(c) $\bar{n} = 0.015$: Drainage area has fairly uniform, gentle slopes with most watercourses either improved or along paved streets. Ground cover consists of some grasses with appreciable areas developed to the extent that a large percentage of the area is impervious.

4. The selected basin $\bar{n}$ factors proved to be in direct proportion to the intercept (C_t) values in the lag curve formula:

$$\text{Lag (in hours)} = C_t \left(\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}} \right)^m$$

where C_t = intercept value of the line whose equation was derived from plotted lag values (see pl. 1)

L = length of longest watercourse, in miles

L_{ca} = length along longest watercourse, measured upstream to a point opposite center of area, in miles

S = over-all slope of drainage area between the headwaters and the collection point, in feet per mile

m = the slope of the lines shown on pl. 1.

The intercepts (C_t) and the basin $\bar{n}$ factors are given in the following table:

Type of drainage area	C_t	$\bar{n}$
Mountain	1.2	0.05
Foothill	.72	.03
Valley	.35	.015

5. An additional basin $\bar{n}$ factor of 0.200 was estimated for another type of drainage area on the basis of research of lag studies by other organizations and investigations and comparison of basin characteristics. This basin factor ($\bar{n}$ = 0.200) was selected for an area with the following characteristics: Drainage area has comparatively uniform slopes and surface characteristics such that channelization does not occur. Ground cover consists of cultivated crops or substantial

growths of grass and fairly dense small shrubs, cacti, or similar vegetation. No drainage improvements exist in the area.

6. Determination of basin $\bar{n}$ factor.--A basin $\bar{n}$ factor can be estimated by comparing characteristics of drainage areas being studied with the characteristics of the drainage areas for which basin $\bar{n}$ factors have been estimated and by comparison with description of pertinent drainage areas given in paragraphs 3 and 5. Estimated basin ($\bar{n}$) factors and pertinent data for drainage areas for which lag values have been determined are listed in table 1. The lag relationships for the drainage areas given in table 1 are shown on plate 2. Also shown on plate 2 is the basic curve (former mountain lag curve) which has a basin $\bar{n}$ factor of 0.05, a C_t of 1.2 and a slope or "m" value of 0.38.

7. Determination of lag.--The lag for the area under consideration is computed by the use of the following equation:

$$Lag_{(\bar{n}=x)} \text{ (in hours)} = \left(\frac{x}{0.05}\right) Lag_{(\bar{n}=0.05)}$$

where $Lag_{(\bar{n}=x)}$ = the area lag required

x = the value of $\bar{n}$ estimated for the area

$Lag_{(\bar{n}=0.05)}$ = the lag obtained from the basic curve whose $\bar{n}$=0.05.

8. Sample computations.--Sample computations for an area with L of 4.1 miles, L_{ca} of 1.5 miles, slope of 226 feet per mile, and estimated basin $\bar{n}$ of 0.025 are as follows: (a) using the above data, value of $\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$ is determined as 0.41; (b) enter plate 2 with the $\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$ value of 0.41 and using the curve with $\bar{n}$ of 0.05, the $Lag_{(\bar{n}=0.05)}$ is determined as 0.86 hour; and (c) with the estimated basin $\bar{n}$ for the area of 0.025 and a $Lag_{(\bar{n}=0.05)}$ of 0.86 hour, the equation presented in paragraph 7 is used to determine $Lag_{(\bar{n}=0.025)}$ of 0.43 hour.

Table 1

Lag relationships - drainage area lag and estimated $\bar{n}$ values

No.	Drainage area*	Regional location**	Lag relationship study: Authority***	Lag relationship study: $\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	Lag relationship study: Lag in hours	Estimated $\bar{n}$#
1	San Gabriel River at San Gabriel Dam.	•	LAD	14.4	3.3	0.05
2	West Fork San Gabriel River at Cogswell Dam.	•	do	1.8	1.6	.05
3	Santa Anita Creek at Santa Anita Dam.	•	do	.55	1.1	.05
4	San Dimas Creek at San Dimas Dam	•	do	2.0	1.5	.05
5	Eaton Wash at Eaton Wash Dam	•	do	1.3	1.3	.05
6	San Antonio Creek near Claremont	•	do	.56	1.2	.055
7	Santa Clara River near Saugus	•	do	48.1	5.6	.05
8	Temecula Creek at Pauba Canyon	•	do	24.0	3.7	.05
9	Santa Margarita River near Fallbrook.	•	do	98.7	7.3	.055
10	Live Oak Creek at Live Oak Dam	•	do	.16	.8	.07
11	Tujunga Creek at Big Tujunga Dam No. 1.	•	do	6.5	2.5	.05
12	East Fullerton Creek at Fullerton Dam.	•	do	.46	.6	.035
13	Los Angeles River at Sepulveda Dam.	•	do	14.2	3.5	.05
14	Pacoima Wash at Pacoima Dam	•	do	6.8	2.4	.05
15	Alhambra Wash above Short Street	•	do	4.7	.6	.015
16	Broadway Drain above Raymond Dike.	•	do	.58	.28	.015

See footnotes at end of table.

Table 1--Continued

Lag relationships - drainage area lag and estimated $\bar{n}$ values--Continued

No.	Drainage area*	Regional location**	Lag relationship study: Authority***	Lag relationship study: $\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	Lag relationship study: Lag in hours	Estimated $\bar{n}$#
17.....	Ballona Creek at Sawtelle Blvd.....	•	LAD.........	8.3	1.2	0.02
18.....	San Jose Creek at Workman Mill Road Bridge.	•	...do........	24.9	2.4	.03
19.....	Murrieta Creek at Temecula.........	•	...do........	28.7	4.0	.05
20.....	San Vicente Creek at Foster........	•	...do........	12.8	3.2	.05
21.....	Santa Margarita River at Ysidora...	•	...do........	227.7	9.5	.055
22.....	San Diego River near Santee........	•	...do........	95.4	9.2	.07
23.....	Santa Ana River at Prado Dam.......	•	...do........	164.9	13.0	.08
24.....	Huasna River near Santa Maria......	•	...do........	45.4	7.0	.07
25.....	Sisquoc River near Gary............	•	...do........	76.8	8.9	.05
26.....	Salinas River near Pozo............	x	...do........	9.0	5.7	.10
27.....	Salinas River at Salinas Reservoir near Pozo.	x	...do........	19.9	7.0	.10
28.....	Deep Creek near Hesperia...........	•	...do........	28.1	##2.8	.05
29.....	West Fork Mojave River near Hesperia.	•	...do........	8.9	##1.0	.055
30.....	Compton Creek near Greenleaf Drive.	•	...do........	21.0	2.3	.015
30a....	Compton Creek below Hooper Avenue storm drain.##	•	...do........	9.7	1.75	.015
31.....	Salt River near Roosevelt, Ariz....	ϕ	...do........	1,574	18.6	.05
32.....	Bill Williams River at Planet, Ariz.	ϕ	...do........	1,476	16.2	.05
33.....	Verde River above Camp Creek, near McDowell, Ariz.	ϕ	...do........	3,618	19.7	.05

See footnotes at end of table.

Table 1--Continued

Lag relationships - drainage area lag and estimated $\bar{n}$ values--Continued

No.	Drainage area*	Regional location**	Lag relationship study			Estimated $\bar{n}$#
			Authority***	$\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	Lag in hours	
34	Gila River at Conner No. 4 damsite, Ariz.	ϕ	LAD	1,727	21.5	0.05
35	San Francisco River at Junction with Blue River, Ariz.	ϕ	...do	1,701	20.6	.05
36	Blue River near Clifton, Ariz.	ϕ	...do	353.4	10.3	.05
37	Gila River near Clifton, Ariz.	ϕ	...do	3,901	35.8	.06
38	Plateau Creek near Cameo, Colo.	o	USBR	89.9	7.9	.06
39	Dolores River near McPhee, Colo.	o	...do	193.3	9.0	.05
40	White River near Watson, Utah	o	...do	1,473	15.7	.04
41	Paria River at Lees Ferry, Ariz.	o	...do	296.0	10.2	.05
42	San Juan River at Pagosa Springs, Colo.	o	...do	16.2	4.0	.06
43	Animas River at Farmington, N. Mex.	o	...do	689.4	12.9	.05
44	San Juan River at Rosa, N. Mex.	o	...do	180.5	8.8	.05
45	San Juan River near Blanco, N. Mex.	o	...do	678.7	15.4	.05
46	San Juan River at Farmington, N. Mex.	o	...do	1,140	19.0	.055
47	Puerco River near Adamana, Ariz.	o	...do	1,225	18.0	.045
48	...do	o	...do	1,225	15.9	.045
49	...do	o	...do	1,225	16.5	.045
50	Clear Creek near Winslow, Ariz.	o	...do	570.4	11.2	.04
51	Moencopi Wash near Tuba City, Ariz.	o	...do	472.7	9.2	.04
52	Arroyo del Valle near Livermore	x	SFD	66.5	10.0	.085
53	Calaveras Reservoir inflow	x	...do	30.6	8.5	.10
54	Corte Madera Creek at Ross	x	...do	2.6	4.6	.12

See footnotes at end of table.

Table 1--Continued

Lag relationships - drainage area lag and estimated $\bar{n}$ values--Continued

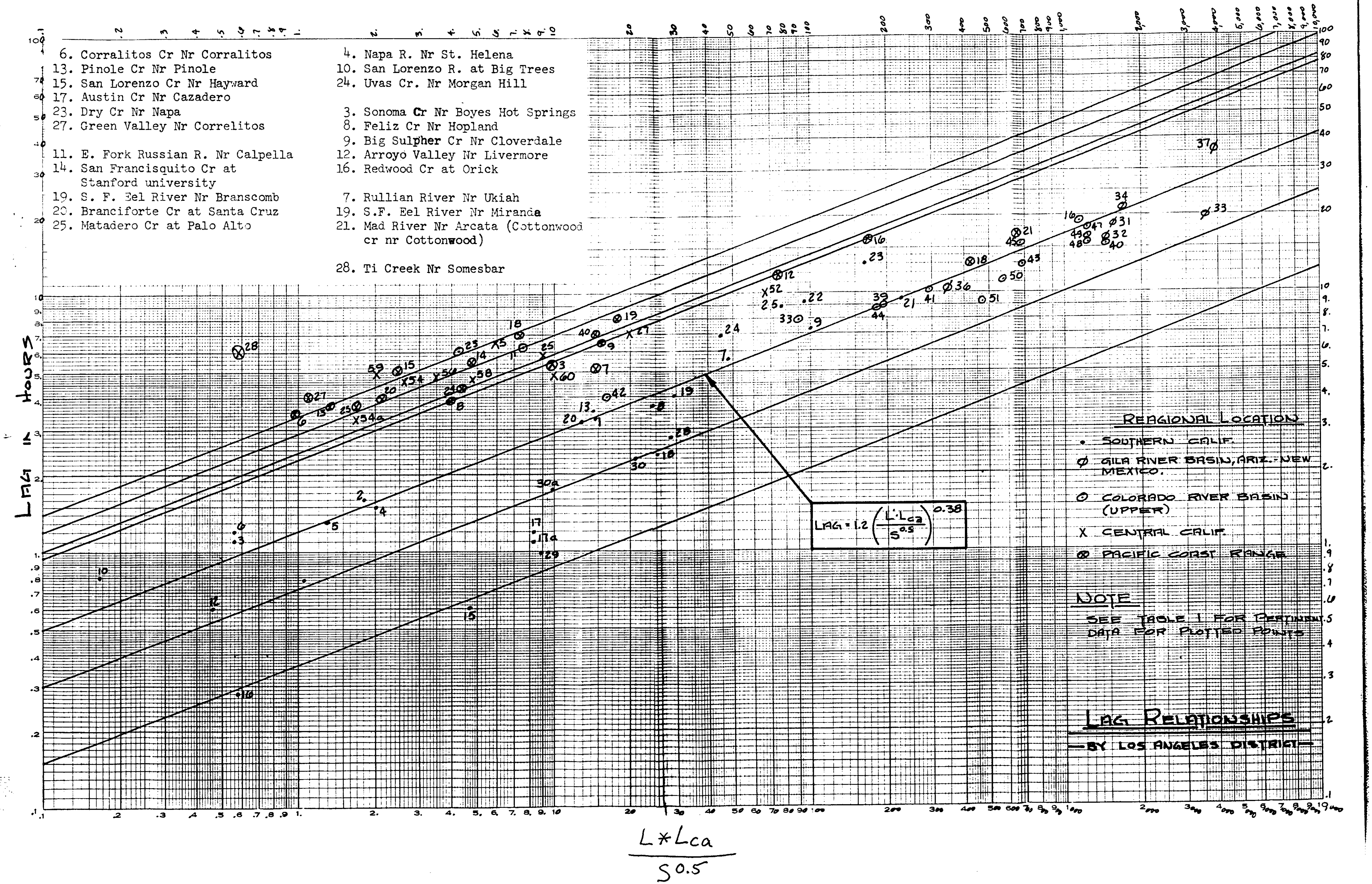
No.	Drainage area*	Regional location**	Lag relationship study: Authority***	Lag relationship study: $\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}$	Lag relationship study: Lag in hours	Estimated $\bar{n}$#
54a	Corte Madera Creek at Ross	x	LAD	1.7	3.3	0.12
55	East Fork Russian River near Calpella.	x	SFD	5.9	6.5	.14
56	Novato Creek near Novato	x	...do	3.5	4.7	.12
57	Pinole Creek near Pinole damsite	x	...do	1.4	3.75	.14
58	San Francisquito Creek near Stanford University.	x	...do	4.8	4.75	.11
59	San Lorenzo Creek at Hayward	x	...do	2.0	4.9	.16
60	Sonoma Creek at Boyes Hot Springs	x	...do	10.0	4.8	.08

* Drainage areas are located in California unless otherwise noted.

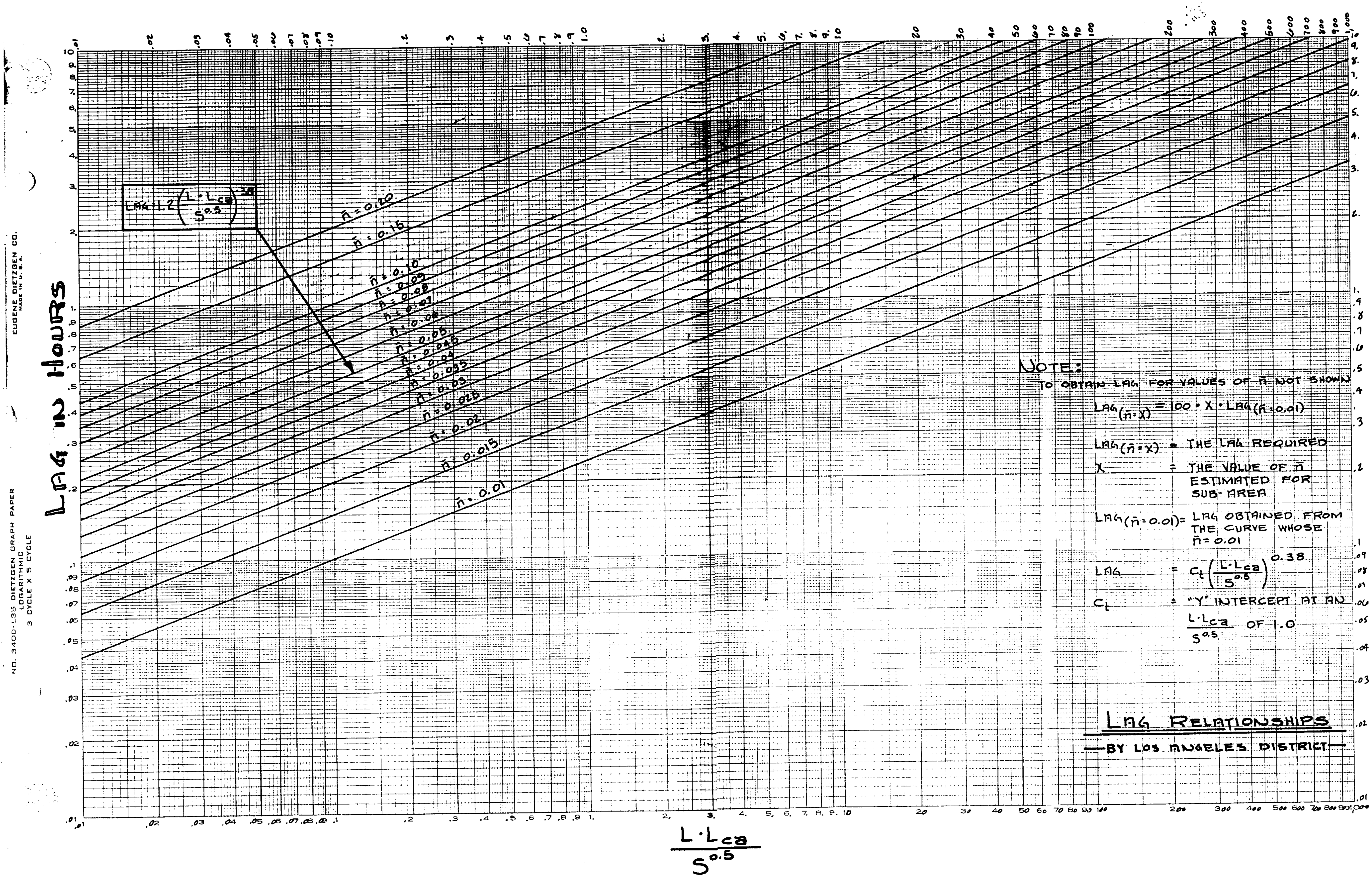
** Regional location:
- • Southern California
- ϕ Gila River basin, Ariz.-N. Mex.
- o Colorado River basin, upper
- x Central California

*** LAD - Los Angeles District
SFD - San Francisco District
USBR - U. S. Bureau of Reclamation

\# More detailed field investigation may indicate changes in some estimated $\bar{n}$ values.
\## Restudy is being made because a preliminary check indicates a longer lag.
\### Transposed hydrograph based on discharges recorded at Greenleaf Drive gaging station.



6. Corralitos Cr Nr Corralitos
13. Pinole Cr Nr Pinole
15. San Lorenzo Cr Nr Hayward
17. Austin Cr Nr Cazadero
23. Dry Cr Nr Napa
27. Green Valley Nr Correlitos
11. E. Fork Russian R. Nr Calpella
14. San Francisquito Cr at Stanford university
19. S. F. Eel River Nr Branscomb
20. Branciforte Cr at Santa Cruz
25. Matadero Cr at Palo Alto
4. Napa R. Nr St. Helena
10. San Lorenzo R. at Big Trees
24. Uvas Cr. Nr Morgan Hill
3. Sonoma Cr Nr Boyes Hot Springs
8. Feliz Cr Nr Hopland
9. Big Sulpher Cr Nr Cloverdale
12. Arroyo Valley Nr Livermore
16. Redwood Cr at Orick
7. Rullian River Nr Ukiah
19. S.F. Eel River Nr Miranda
21. Mad River Nr Arcata (Cottonwood cr nr Cottonwood)
28. Ti Creek Nr Somesbar
LAG IN HOURS
$\frac{L*L_{ca}}{S^{0.5}}$
$LAG = 1.2\left(\frac{L \cdot L_{ca}}{S^{0.5}}\right)^{0.38}$
REAGIONAL LOCATION
• SOUTHERN CALIF.
ø GILA RIVER BASIN, ARIZ.-NEW MEXICO.
○ COLORADO RIVER BASIN (UPPER)
X CENTRAL CALIF.
⊗ PACIFIC COAST RANGE
NOTE
SEE TABLE I FOR PERTINENT DATA FOR PLOTTED POINTS
LAG RELATIONSHIPS
BY LOS ANGELES DISTRICT



LAG IN HOURS
LAG = 1.2 (L · Lca / S0.5)^.38
n̄ = 0.20
n̄ = 0.15
n̄ = 0.10
n̄ = 0.09
n̄ = 0.08
n̄ = 0.07
n̄ = 0.06
n̄ = 0.05
n̄ = 0.045
n̄ = 0.04
n̄ = 0.035
n̄ = 0.03
n̄ = 0.025
n̄ = 0.02
n̄ = 0.015
n̄ = 0.01
NOTE:
TO OBTAIN LAG FOR VALUES OF n̄ NOT SHOWN
LAG(n̄=X) = 100 · X · LAG(n̄=0.01)
LAG(n̄=X) = THE LAG REQUIRED
X = THE VALUE OF n̄ ESTIMATED FOR SUB-AREA
LAG(n̄=0.01) = LAG OBTAINED FROM THE CURVE WHOSE n̄ = 0.01
LAG = Ct (L·Lca / S0.5)^0.38
Ct = "Y" INTERCEPT AT AN L·Lca / S0.5 OF 1.0
LAG RELATIONSHIPS
BY LOS ANGELES DISTRICT
L · Lca / S0.5
EUGENE DIETZGEN CO. MADE IN U.S.A.
NO. 340D-L35 DIETZGEN GRAPH PAPER LOGARITHMIC 3 CYCLE X 5 CYCLE

Dick — here is description of the UAG Theory / A.L.

distribution graph was derived for subarea WN-8 because the porous soil and the large number of depressions in the subarea were assumed to result in negligible run-off. For subareas WN-39 and -40, which are reservoir sites, a distribution of 100 percent during the first unit period was assumed. Distribution graphs were derived synthetically for the other 34 subareas because run-off records were not available for the concentration points of those areas. Details of the derivation of distribution graphs are given in following paragraphs.

70. Derivation of distribution graphs. - The method used in these studies for deriving and applying unit graphs and distribution graphs is approximately the same as that described in United States Geological Survey Water-Supply Paper No. 772 and in numerous technical papers included in publications of the American Society of Civil Engineers and the American Geophysical Union. Although most terms used in the flood syntheses described in this report are defined in those papers, an explanation of some of the terms is given below for the convenience of the reader.

a. Effective rainfall is that part of the rainfall that remains on the surface of an area after infiltration, evaporation, transpiration, absorption, and detention, and that results in run-off. Effective rainfall is equivalent in quantity to surface run-off.

b. A unit graph for a given point on a given stream is a curve (a hydrograph) showing the time distribution of rates of run-off that would result at that point from unit effective rainfall over the drainage area above that point. (A unit graph for the concentration point of a drainage area is also called the unit graph for that area.)

c. A distribution graph is a unit graph whose ordinates are expressed as run-off in percent of unit run-off. As used for this report, a distribution graph is constructed as a block graph, each block representing the percent of unit run-off that results during unit time.

d. A summation hydrograph for a given point on a given stream is a curve (a hydrograph) showing the time distribution of the rates of run-off that would result from an assumed continuous series of unit effective rainfalls over the drainage area above that point. The ordinates of the summation hydrographs used for this report are expressed as rate of run-off in percent of ultimate (maximum) rate of run-off, and the abscissae are expressed as time units. (For further explanation, see under a subsequent heading, "Summation hydrograph.")

e. Lag for a drainage area is the elapsed time (in hours) from the beginning of an assumed continuous series of unit effective rainfalls over the area to the instant at which the rate of the resulting run-off at the area concentration point equals 50 percent of the maximum (ultimate) rate of the resulting run-off at that point. (For further explanation, see under a subsequent heading, "Lag.")

f. An S-graph is a summation hydrograph developed by plotting discharge in percent of ultimate discharge versus time in percent of lag. (For further explanation, see under a subsequent heading, "S-graph.")

71. Adequate rainfall and run-off data are available for the derivation of distribution graphs for eight points in and near the drainage area above Whittier Narrows: (1) San Gabriel River at San Gabriel Dam No. 2, the concentration point of subarea WN-2; (2) San Gabriel River at San Gabriel Dam No. 1, the concentration point of subarea WN-1; (3) Eaton Wash at Eaton Wash Dam, the concentration point of subarea WN-13; (4) Santa Anita Creek at Santa Anita Dam, a point in the lower part of subarea WN-18; (5) San Dimas Creek at San Dimas Dam, a point in the lower part of subarea WN-26; (6) San Jose Creek at Workman Mill Road, a point just downstream from the concentration point of subarea WN-36; (7) Broadway drain at Raymond dike, a point in the upper part of subarea WN-11; and (8) Alhambra Wash at Short Street, a point in the lower part of subarea WN-11. The location of these eight points is shown on plate 19. Broadway drain and Alhambra Wash, which are paved channels, drain urban and suburban areas, and San Jose Creek, which is unimproved, drains a hill and valley area that is principally agricultural. The other five streams drain mountain areas.

72. Distribution graphs for each of the eight points were derived by trial-and-error reproductions of hydrographs for the 1938 flood. The reproduced flood hydrographs together with tabulations

of the distribution-graph percentages are shown on plates 41 to 48 inclusive. These hydrographs were used because the 1938 flood not only was the greatest for which adequate data are available but also was the largest of historic record. Therefore, 1938 flood flows were considered more indicative of design flood flows. The derived distribution graphs were corroborated by using them to reproduce hydrographs for the flood of January 1943. Analyses of all major floods were impracticable because of the lack of sufficient run-off and rainfall data.

73. Data from all eight graphs supplemented by similar data for other drainage areas in southern California were used to develop synthetic distribution graphs for 34 subareas for which adequate data were not available for developing distribution graphs. Details of the development of those synthetic distribution graphs are given in following paragraphs.

74. Derivation of synthetic distribution graphs. - The method of determining synthetic distribution graphs described in this report is generally similar to that method developed by F. F. Snyder and modified by W. B. Langbein that is discussed in Transactions of the American Geophysical Union, pages 447-454 of Part I, 1938, and page 626 of Part II, 1940. The method is used in determining the time distribution of run-off in drainage areas for which concentration-point hydrographs are not available. The method provides for transposing to those areas the characteristic time distribution of run-off in near-by drainage areas for which such distribution can be determined;

should be similar

the transposed distribution is usually the average distribution for several areas. Use of the method is considered practicable when drainage areas within a given region are physiographically and hydrologically similar. The experience of this office indicates that the assumption of such similarity between areas in the southern California region is valid, and that results based on that assumption are accurate within acceptable limits.

75. Because no two drainage areas have identical physical characteristics, such as area, dimensions, stream-channel pattern, channel lengths, and stream slopes, the run-offs from those areas never concentrate alike, and the distribution graphs of those areas are never identical except by chance. Therefore, direct transposition of distribution graphs from one area to another is usually precluded. However, most distribution graphs are generally similar, and the introduction of a factor (parameter) called "lag" will bring the general arrangement of ordinates along the bases of distribution graphs into a generally consistent relationship. Lag, which was first defined in part by W. W. Horner and F. L. Flynt in Transactions, American Society of Civil Engineers, Vol. 101, 1936, as the "time difference in phase between salient features of the rainfall and run-off rate curves," is an empirical expression of the physical characteristics of a drainage area in terms of time. Details of the determination of lag for areas for which characteristic time distributions of run-off are known and of the use of lag in developing synthetic distribution graphs for 34 subareas above Whittier Narrows are as follows:

a. Summation hydrograph. - The first step in determining lag for a drainage area consists of constructing a curve called a summation hydrograph, which is the hydrograph of run-off that would result from the continuous generation of unit effective rainfall over the area. For this report, the ordinates of summation hydrographs are expressed as discharge in percent of ultimate discharge, and a summation hydrograph for a given point on a given stream is derived by algebraically adding a continuous series of identical distribution graphs out of phase one unit period. On such a hydrograph, the time required to reach maximum (ultimate) discharge is equal to the length of the base of one distribution graph less one unit period. The mean half-hourly percentages of discharge from the distribution graph derived for San Gabriel River at San Gabriel Dam No. 2 (see pl. 41) are tabulated in column 2 of table 28, and the successive accumulations of those percentages are tabulated in column 3. From data on these percentages, the summation hydrograph for San Gabriel Dam No. 2 was plotted to show time versus discharge in percent of ultimate discharge (see pl. 49). Summation hydrographs were developed similarly for the other seven points mentioned under a preceding heading, "Derivation of distribution graphs."

This makes it a 1/2 hr u.h.?

b. Lag. - The definitions given for lag and summation hydrograph under a preceding heading, "Derivation of distribution graphs," indicate that lag for a drainage area may also be defined as the elapsed time (in hours) from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of that area reaches 50 percent of ultimate discharge. For example, the lag for the drainage area above San Gabriel Dam No. 2 (WN-2) is estimated at 1.6 hours (see pl. 49). When the lags that are determined from summation hydrographs developed from observed hydrologic data for several similar drainage areas are correlated to the physical characteristics of those areas an empirical relationship is usually apparent. This relationship can then be used to determine the lags for comparable drainage areas for which the physical characteristics can be determined, but for which the distribution graphs for concentration points cannot be determined because of inadequate hydrologic data. Measuring the lags for the areas above the eight points mentioned under a preceding heading, "Derivation of distribution graphs," indicated that lags for those areas could be expressed by the empirical formula:

$$\text{Lag (in hours)} = C_t\left(\frac{L \times L_{ca}}{S^{\frac{1}{2}}}\right)^m$$

where C_t = a constant (see below)

L = length of longest watercourse, in miles

L_{ca} = length along longest watercourse, measured upstream to a point opposite center of area, in miles

S = over-all slope of drainage area between the headwaters and the collection point, in feet per mile

m = a constant (see below).

On plate 50 is shown the derivation of this equation, accomplished by plotting, to logarithmic scale, observed lag versus $\frac{L \times L_{ca}}{S^{\frac{1}{2}}}$. The plotted points for the lags of the five mountain drainage areas suggest a straight line whose slope, m, is 0.36 and whose intercept, C_t, is 1.2. Adequate corroboration of the relationship expressed by this formula is indicated by the position of the line, shown plotted on plate 50, fitted to these five lag points and to lag points for seven comparable drainage areas in the southern California region. The same relationship does not apply to the three valley and hill drainages. (The determination of all factors that should be included in the formula to make one relationship applicable to all types of areas appears infeasible because available data are inadequate.) However, the assumption is reasonable that the lags for the valley subareas can be determined from the relationship expressed by a straight line that is parallel to the line for the mountain areas and fitted to the plotted lag points for the areas above Alhambra Wash at Short Street and Broadway drain at Raymond dike (two of the three valley and hill areas), because the derived lags for these two areas are representative of the lags for areas with paved collecting channels, and because the design flood is assumed to occur after the channels of all principal tributaries in the valley area above Whittier Narrows have been paved.

c. S-graph. - When lags were determined for the areas above the eight considered points, the next step in determining synthetic distribution graphs was the development of S-graphs, which are summation hydrographs modified to the extent that percent of ultimate discharge is plotted versus time in percent of lag. In other words, the derivation of an S-graph is identical to the derivation of a summation hydrograph, except that the factor of lag has been introduced. Time in percent of lag for use in developing the S-graph for the area above San Gabriel Dam No. 2 (subarea WN-2) is given in column 4 of table 28, S-graphs for the five mountain areas including subarea WN-2 are shown on plate 51, and S-graphs for the three valley areas are shown on plate 52. In conformity with the definition of lag, the S-graph reaches 50 percent of ultimate discharge at 100 percent of lag. This fact is helpful in using S-graphs to compare run-off characteristics of various drainage areas. The average of the S-graphs for the four mountain areas (pl. 53) was assumed to be applicable to the mountain subareas with unknown run-off characteristics, and similarly the average of the S-graphs for two of the three valley areas (pl. 53) was assumed to be applicable to the valley subareas.

Lag curves used to read.

d. Application of lag and S-graphs. - The final steps in determining synthetic distribution graphs for 34 subareas for which run-off characteristics are unknown can be illustrated by reviewing the final steps required in determining the synthetic distribution graph for one of those subareas, say mountain subarea WN-21. First, values of L, L_{ca}, and S were determined from topographic data, and the value of $\frac{L \times L_{ca}}{S^{\frac{1}{2}}}$ was computed as 0.41. Then, from the lag curve applicable to mountain areas (pl. 50), lag for a value of 0.41 was determined to be 0.9 hour. Next, a unit time of 20 minutes was selected, and accumulated unit-time periods were expressed as accumulated percentages of the 0.9-hour lag (see column 2 of table 29).

Then, these percentages of lag were used in superimposing a "block" graph on the average S-graph for mountain subareas, and the resultant pattern was used in determining the accumulated mean percentage of ultimate discharge for each accumulated unit time (pl. 54). These accumulated mean percentages are tabulated in column 3 of table 29. Then, because these accumulated mean percentages represent the accumulated mean percentages for the synthetic distribution graph for subarea WN-21, the mean percentages for successive unit periods were determined by a series of subtractions. These percentages are tabulated in column 4 of table 29. Synthetic distribution-graph mean percentages were derived similarly for 33 other subareas for which adequate run-off data were not available. However, the lag curve and the average S-graph for valley areas were used in the derivation of synthetic distribution-graph mean percentages for valley subareas. Pertinent data on lag for the 40 subareas are given in table 30, and pertinent data on distribution-graph percentages are given in table 31.

76. Reservoir design storm. - As stated under a preceding heading, "General," the reservoir design storm would be equal in magnitude to the storm of January 1943. Consequently, the total storm isohyetal map for the storm of January 1943 over the drainage area (pl. 27) was used in determining the average depth of total design-storm precipitation in each subarea. Each of these average depths was converted to a unit-time pattern of rainfall intensity by using records of automatic rainfall gages in and near the subarea.

METHOD USED TO DEVELOP
UNIT HYDROGRAPHS
FOR THE
U. S. ARMY ENGINEER DISTRICT, LOS ANGELES
CORPS OF ENGINEERS

The following excerpts were taken from the district engineer's report titled "Hydrology, San Gabriel River and the Rio Hondo Above Whittier Narrows Flood-Control Basin with Addendum on the Hydrologic Effect of Diverting Outflow from Whittier Narrows Flood-Control Basin to Los Angeles River Via the Rio Hondo," dated 20 December 1944 and revised 10 July 1946.

70. Derivation of distribution graphs. - The method used in these studies for deriving and applying unit graphs and distribution graphs is approximately the same as that described in United States Geological Survey Water-Supply Paper No. 772 and in numerous technical papers included in publications of the American Society of Civil Engineers and the American Geophysical Union. Although most terms used in the flood syntheses described in this report are defined in those papers, an explanation of some of the terms is given below for the convenience of the reader.

a. Effective rainfall is that part of the rainfall that remains on the surface of an area after infiltration, evaporation, transpiration, absorption, and detention, and that results in run-off. Effective rainfall is equivalent in quantity to surface run-off.

b. A unit graph for a given point on a given stream is a curve (a hydrograph) showing the time distribution of rates of run-off that would result at that point from unit effective rainfall over the drainage area above that point. (A unit graph for the concentration point of a drainage area is also called the unit graph for that area.)

c. A distribution graph is a unit graph whose ordinates are expressed as run-off in percent of unit run-off. As used for this report, a distribution graph is constructed as a block graph, each block representing the percent of unit run-off that results during unit time.

d. A summation hydrograph for a given point on a given stream is a curve (a hydrograph) showing the time distribution of the rates of run-off that would result from an assumed continuous series of unit effective rainfalls over the drainage area above that point. The ordinates of the summation hydrographs used for this report are expressed as rate of run-off in percent of ultimate (maximum) rate of run-off, and the abscissae are expressed as time units. (For further explanation, see under a subsequent heading, "Summation hydrograph.")

e. Lag for a drainage area is the elapsed time (in hours) from the beginning of an assumed continuous series of unit effective rainfalls over the area to the instant at which the rate of the resulting run-off at the area concentration point equals 50 percent of the maximum (ultimate) rate of the resulting run-off at that point. (For further explanation, see under a subsequent heading, "Lag.")

f. An S-graph is a summation hydrograph developed by plotting discharge in percent of ultimate discharge versus time in percent of lag. (For further explanation, see under a subsequent heading, "S-graph.")

71. Adequate rainfall and run-off data are available for the derivation of distribution graphs for eight points in and near the drainage area above Whittier Narrows: (1) San Gabriel River at San Gabriel Dam No. 2, the concentration point of subarea WN-2; (2) San Gabriel River at San Gabriel Dam No. 1, the concentration point of subarea WN-1; (3) Eaton Wash at Eaton Wash Dam, the concentration point of subarea WN-13; (4) Santa Anita Creek at Santa Anita Dam, a point in the lower part of subarea WN-18; (5) San Dimas Creek at San Dimas Dam, a point in the lower part of subarea WN-26; (6) San Jose Creek at Workman Mill Road, a point just downstream from the concentration point of subarea WN-36; (7) Broadway drain at Raymond dike, a point in the upper part of subarea WN-11; and (8) Alhambra Wash at Short Street, a point in the lower part of subarea WN-11. The location of these eight points is shown on plate 19. Broadway drain and Alhambra Wash, which are paved channels, drain urban and suburban areas, and San Jose Creek, which is unimproved, drains a hill and valley area that is principally agricultural. The other five streams drain mountain areas.

72. Distribution graphs for each of the eight points were derived by trial-and-error reproductions of hydrographs for the 1938 flood. The reproduced flood hydrographs together with tabulations

of the distribution-graph percentages are shown on plates 41 to 48 inclusive. These hydrographs were used because the 1938 flood not only was the greatest for which adequate data are available but also was the largest of historic record. Therefore, 1938 flood flows were considered more indicative of design flood flows. The derived distribution graphs were corroborated by using them to reproduce hydrographs for the flood of January 1943. Analyses of all major floods were impracticable because of the lack of sufficient run-off and rainfall data.

73. Data from all eight graphs supplemented by similar data for other drainage areas in southern California were used to develop synthetic distribution graphs for 34 subareas for which adequate data were not available for developing distribution graphs. Details of the development of those synthetic distribution graphs are given in following paragraphs.

74. Derivation of synthetic distribution graphs. - The method of determining synthetic distribution graphs described in this report is generally similar to that method developed by F. F. Snyder and modified by W. B. Langbein that is discussed in Transactions of the American Geophysical Union, pages 447-454 of Part I, 1938, and page 626 of Part II, 1940. The method is used in determining the time distribution of run-off in drainage areas for which concentration-point hydrographs are not available. The method provides for transposing to those areas the characteristic time distribution of run-off in near-by drainage areas for which such distribution can be determined;

the transposed distribution is usually the average distribution for several areas. Use of the method is considered practicable when drainage areas within a given region are physiographically and hydrologically similar. The experience of this office indicates that the assumption of such similarity between areas in the southern California region is valid, and that results based on that assumption are accurate within acceptable limits.

75. Because no two drainage areas have identical physical characteristics, such as area, dimensions, stream-channel pattern, channel lengths, and stream slopes, the run-offs from those areas never concentrate alike, and the distribution graphs of those areas are never identical except by chance. Therefore, direct transposition of distribution graphs from one area to another is usually precluded. However, most distribution graphs are generally similar, and the introduction of a factor (parameter) called "lag" will bring the general arrangement of ordinates along the bases of distribution graphs into a generally consistent relationship. Lag, which was first defined in part by W. W. Horner and F. L. Flynt in Transactions, American Society of Civil Engineers, Vol. 101, 1936, as the "time difference in phase between salient features of the rainfall and run-off rate curves," is an empirical expression of the physical characteristics of a drainage area in terms of time. Details of the determination of lag for areas for which characteristic time distributions of run-off are known and of the use of lag in developing synthetic distribution graphs for 34 subareas above Whittier Narrows are as follows:

a. Summation hydrograph. - The first step in determining lag for a drainage area consists of constructing a curve called a summation hydrograph, which is the hydrograph of run-off that would result from the continuous generation of unit effective rainfall over the area. For this report, the ordinates of summation hydrographs are expressed as discharge in percent of ultimate discharge, and a summation hydrograph for a given point on a given stream is derived by algebraically adding a continuous series of identical distribution graphs out of phase one unit period. On such a hydrograph, the time required to reach maximum (ultimate) discharge is equal to the length of the base of one distribution graph less one unit period. The mean half-hourly percentages of discharge from the distribution graph derived for San Gabriel River at San Gabriel Dam No. 2 (see pl. 41) are tabulated in column 2 of table 28, and the successive accumulations of those percentages are tabulated in column 3. From data on these percentages, the summation hydrograph for San Gabriel Dam No. 2 was plotted to show time versus discharge in percent of ultimate discharge (see pl. 49). Summation hydrographs were developed similarly for the other seven points mentioned under a preceding heading, "Derivation of distribution graphs."

b. Lag. - The definitions given for lag and summation hydrograph under a preceding heading, "Derivation of distribution graphs," indicate that lag for a drainage area may also be defined as the elapsed time (in hours) from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of that area reaches 50 percent of ultimate discharge. For example, the lag for the drainage area above San Gabriel Dam No. 2 (WN-2) is estimated at 1.6 hours (see pl. 49). When the lags that are determined from summation hydrographs developed from observed hydrologic data for several similar drainage areas are correlated to the physical characteristics of those areas, an empirical relationship is usually apparent. This relationship can then be used to determine the lags for comparable drainage areas for which the physical characteristics can be determined, but for which the distribution graphs for concentration points cannot be determined because of inadequate hydrologic data. Measuring the lags for the areas above the eight points mentioned under a preceding heading, "Derivation of distribution graphs," indicated that lags for those areas could be expressed by the empirical formula:

$$\text{Lag (in hours)} = C_t\left(\frac{L \times L_{ca}}{S^{\frac{1}{2}}}\right)^m$$

where C_t = a constant (see below)

L = length of longest watercourse, in miles

L_{ca} = length along longest watercourse, measured upstream to a point opposite center of area, in miles

S = over-all slope of drainage area between the headwaters and the collection point, in feet per mile

m = a constant (see below).

On plate 50 is shown the derivation of this equation, accomplished by plotting, to logarithmic scale, observed lag versus $\frac{L \times L_{ca}}{S^{\frac{1}{2}}}$. The plotted points for the lags of the five mountain drainage areas suggest a straight line whose slope, m, is 0.36 and whose intercept, C_t, is 1.2. Adequate corroboration of the relationship expressed by this formula is indicated by the position of the line, shown dotted on plate 50, fitted to these five lag points and to lag points for seven comparable drainage areas in the southern California region. The same relationship does not apply to the three valley and hill drainages. (The determination of all factors that should be included in the formula to make one relationship applicable to all types of areas appears infeasible because available data are inadequate.) However, the assumption is reasonable that the lags for the valley subareas can be determined from the relationship expressed by a straight line that is parallel to the line for the mountain areas and fitted to the plotted lag points for the areas above Alhambra Wash at Short Street and Broadway drain at Raymond dike (two of the three valley and hill areas), because the derived lags for these two areas are representative of the lags for areas with paved collecting channels, and because the design flood is assumed to occur after the channels of all principal tributaries in the valley area above Whittier Narrows have been paved.

c. S-graph. - When lags were determined for the areas above the eight considered points, the next step in determining synthetic distribution graphs was the development of S-graphs, which are summation hydrographs modified to the extent that percent of ultimate discharge is plotted versus time in percent of lag. In other words, the derivation of an S-graph is identical to the derivation of a summation hydrograph, except that the factor of lag has been introduced. Time in percent of lag for use in developing the S-graph for the area above San Gabriel Dam No. 2 (subarea WN-2) is given in column 4 of table 28, S-graphs for the five mountain areas including subarea WN-2 are shown on plate 51, and S-graphs for the three valley areas are shown on plate 52. In conformity with the definition of lag, the S-graph reaches 50 percent of ultimate discharge at 100 percent of lag. This fact is helpful in using S-graphs to compare run-off characteristics of various drainage areas. The average of the S-graphs for the four mountain areas (pl. 53) was assumed to be applicable to the mountain subareas with unknown run-off characteristics, and similarly the average of the S-graphs for two of the three valley areas (pl. 53) was assumed to be applicable to the valley subareas.

d. Application of lag and S-graphs. - The final steps in determining synthetic distribution graphs for 34 subareas for which run-off characteristics are unknown can be illustrated by reviewing the final steps required in determining the synthetic distribution graph for one of those subareas, say mountain subarea WN-21. First, values of L, L_{ca}, and S were determined from topographic data, and the value of $\frac{L \times L_{ca}}{S^{\frac{1}{2}}}$ was computed as 0.41. Then, from the lag curve applicable to mountain areas (pl. 50), lag for a value of 0.41 was determined to be 0.9 hour. Next, a unit time of 20 minutes was selected, and accumulated unit-time periods were expressed as accumulated percentages of the 0.9-hour lag (see column 2 of table 29).

Then, these percentages of lag were used in superimposing a "block" graph on the average S-graph for mountain subareas, and the resultant pattern was used in determining the accumulated mean percentage of ultimate discharge for each accumulated unit time (pl. 54). These accumulated mean percentages are tabulated in column 3 of table 29. Then, because these accumulated mean percentages represent the accumulated mean percentages for the synthetic distribution graph for subarea WN-21, the mean percentages for successive unit periods were determined by a series of subtractions. These percentages are tabulated in column 4 of table 29. Synthetic distribution-graph mean percentages were derived similarly for 33 other subareas for which adequate run-off data were not available. However, the lag curve and the average S-graph for valley areas were used in the derivation of synthetic distribution-graph mean percentages for valley subareas. Pertinent data on lag for the 40 subareas are given in table 30, and pertinent data on distribution-graph percentages are given in table 31.

Table 28

Determination of summation graph and lag interval for San Gabriel River at San Gabriel Dam No. 2, subarea WN-2*

(1) Number of unit period**	(2) UNIT GRAPH Distribution-graph mean percentage***	(3) Accumulated distribution-graph mean percentage	(4) Time in percent of lag****
1	1.7	1.7	0-31
2	10.3	12.0	31-62
3	31.0	43.0	62-94
4	10.0	53.0	94-125
5	6.5	59.5	125-156
6	5.3	64.8	156-188
7	4.2	69.0	188-219
8	3.7	72.7	219-250
9	3.2	75.9	250-281
10	2.7	78.6	281-312
11	2.0	80.6	312-344
12	1.7	82.3	344-375
13	1.6	83.9	375-406
14	1.5	85.4	406-438
15	1.4	86.8	438-469
16	1.3	88.1	469-500
17	1.2	89.3	500-531
18	1.1	90.4	531-562
19	1.0	91.4	562-594
20	1.0	92.4	594-625
21	.9	93.3	625-656
22	.9	94.2	656-688
23	.8	95.0	688-719
24	.7	95.7	719-750
25	.6	96.3	750-781
26	.5	96.8	781-812
27	.5	97.3	812-844
28	.4	97.7	844-875
29	.4	98.1	875-906
30	.4	98.5	906-938
31	.3	98.8	938-969
32	.3	99.1	969-1,000
33	.3	99.4	1,000-1,031
34	.2	99.6	1,031-1,062
35	.2	99.8	1,062-1,094
36	.1	99.9	1,094-1,125
37	.1	100.0	1,125-1,156

* Data in columns 1, 2, and 3 are used in developing summation graph (pl. 49), and data in column 4 are developed by using the lag value determined from the summation graph.

** Unit period is 30 minutes.

*** See pl. 41

**** Lag is 1.6 hours (see pls. 49 and 50).

Table 29

Determination of distribution-graph percentages from average S-graph, subarea WN-21 in drainage area above Whittier Narrows Dam site

(1) Number of unit period*	(2) Time in percent of lag**	(3) Accumulated distribution-graph mean percentage***	(4) Distribution-graph mean percentage
1	0-37	4.6	4.6
2	37-74	24.5	19.9
3	74-111	47.5	23.0
4	111-148	57.9	10.4
5	148-185	64.5	6.6
6	185-222	69.8	5.3
7	222-259	73.8	4.0
8	259-296	77.1	3.3
9	296-333	79.9	2.8
10	333-370	82.3	2.4
11	370-407	84.2	1.9
12	407-444	86.0	1.8
13	444-482	87.5	1.5
14	482-519	88.8	1.3
15	519-556	90.0	1.2
16	556-593	91.1	1.1
17	593-630	92.2	1.1
18	630-667	93.2	1.0
19	667-704	94.1	.9
20	704-741	94.9	.8
21	741-778	95.6	.7
22	778-815	96.2	.6
23	815-852	96.8	.6
24	852-889	97.4	.6
25	889-926	97.9	.5
26	926-963	98.3	.4
27	963-1,000	98.6	.3
28	1,000-1,037	98.9	.3
29	1,037-1,074	99.2	.3
30	1,074-1,111	99.4	.2
31	1,111-1,148	99.6	.2
32	1,148-1,185	99.7	.1
33	1,185-1,222	99.8	.1
34	1,222-1,259	99.9	.1
35	1,259-1,296	100.0	.1

* Unit period is 20 minutes.
** Lag is 0.9 hour (see pl.50).
*** See pl. 54.

Table 35

Average rainfall loss rates during period of 1-3 March in 1938 storm, various areas in drainage area above Whittier Narrows Dam site

Stream	Concentration point	Drainage area		Average loss rate	
		Pervious	All-impervious	Pervious area	All-impervious area
		Square miles	Square miles	Inches per hour	Inches per hour
Alhambra Wash	Short Street	10.4	3.6	0.44	0.03
Big Dalton Creek	Big Dalton Dam	4.5	....	.39	....
Broadway Drain	Raymond Dike	1.6	.8	.28	.03
Eaton Wash	Eaton Wash Dam	9.5	....	.52	....
San Dimas Creek	San Dimas Dam	16.2	....	.43	....
San Gabriel River	San Gabriel Dam No. 1	*161.6	....	.40	....
San Gabriel River, West Fork	San Gabriel Dam No. 2	40.4	....	.35	....
San Jose Creek	Workman Mill Road	**81.3	Negligible	.22	Negligible
Santa Anita Creek	Santa Anita Dam	10.8	....	.43	....
Walnut Creek	Covina Boulevard	***59.4	Negligible	.39	Negligible
Do	Puddingstone Dams Nos. 1, 2, and 3	****13.4	....	.25	....

* Excludes area above San Gabriel Dam No. 2.
** Excludes area above Thompson Creek Dam.
*** Excludes area above mouth of Big Dalton Canyon and above Puddingstone Diversion Dam and Puddingstone Dams Nos. 1, 2, and 3.
**** Excludes area above Puddingstone Diversion and San Dimas Dams.

Table 37

Base flow factors from reproductions of 1938 flood hydrographs, drainage area above Whittier Narrows Dam site

Concentration point	Base flow factors: Discharge at beginning of surface run-off	Base flow factors: Peak discharge	Base flow factors: Recession*	Subarea to which factors are assumed applicable for reservoir design flood**
	Cubic feet per second per square mile	Cubic feet per second per square mile		
San Gabriel River at San Gabriel Dam No. 1.	17	53	0.98	WN-1
San Gabriel River, West Fork, at San Gabriel Dam No. 2.	12	50	.93	WN-2
Eaton Wash at Eaton Wash Dam.	11	36	.94	WN-13, -14, -15
Santa Anita Creek at Santa Dam.	22	105	.76	WN-5, -6, -7, -9, -18, -21, -23
San Dimas Creek at San Dimas Dam.	6	20	.97	WN-3, -4, -26, -27, -28, -29, -30, -32, -33, -35

* Recession factor = $\frac{Q_n}{Q_1}$

Where Q_1 = Peak base-flow discharge or any instantaneous base-flow discharge occurring after peak base-flow discharge.

Q_n = Instantaneous base-flow discharge occurring 6 hours after any given Q_1.

** A constant base flow of 5 cubic feet per second per square mile was used for valley subareas and for subareas that are mostly in the valley.

THE SYNTHETIC UNIT HYDROGRAPH

Development of the Synthetic Unit Hydrograph.--A unit hydrograph for any given concentration point within a drainage area is a curve showing the time distribution of rates of runoff that would result at that concentration point from a unit of effective rainfall over the drainage area above that point.

For areas where there is little observational data available concerning rainfall-runoff relationships use is made of data compiled from physiographically and hydrologically similar areas considered applicable to the study area. This method determines the unit hydrograph synthetically on the basis of data collected in neighboring drainage basins. The method transposes to areas for which data are not available, the characteristic time distribution of runoff from nearby drainage areas for which such data are available.

Because no two drainage basins have the same physical characteristics, it is necessary to adjust for differences in these characteristics. This adjustment is accomplished by using a factor called lag. Lag for a drainage area is defined as the elapsed time in hours from the beginning of unit effective rainfall to the instant that the summation hydrograph for the concentration point of an area reaches 50 percent of ultimate discharge. Lag is an empirical expression of the physical characteristics of a drainage area in terms of time.

Lag can be expressed by the empirical formula:

$$\text{Lag (hours)} = C\left(\frac{L \cdot L_{ca}}{S^{\frac{1}{2}}}\right)^{m}$$

Where C = a constant, 1.20

m = a constant, 0.38

L = length of longest watercourse, in miles.

L_{ca} = length along longest watercourse, measured upstream to a point opposite the centroid of the area, in miles.

S = overall slope of drainage area between the headwaters and the collection point, in feet per mile.

Determination of basin $\bar{n}$ factor.--A basin $\bar{n}$ factor can be estimated by comparing characteristics of drainage areas being studied with the characteristics of the drainage areas for which basin $\bar{n}$ factors have been estimated.

Guide for estimating basin factor ($\bar{n}$):

$\bar{n} = 0.200$: Drainage area has comparatively uniform slopes and surface characteristics such that channelization does not occur. Ground cover consists of cultivated crops or substantial growths of grass and fairly dense small shrubs, or cacti, or similar vegetation. No drainage improvements exist in the area.

$\bar{n} = 0.050$: Drainage area is quite rugged, with sharp ridges and narrow, steep canyons through which watercourses meander around sharp bends, over large boulders, and considerable debris obstruction. The ground cover, excluding small areas of rock outcrops, includes many trees and considerable underbrush. No drainage improvements exist in the area.

$\bar{n} = 0.030$: Drainage area is generally rolling, with rounded ridges and moderate side slopes. Watercourses meander in fairly straight, unimproved channels with some boulders and lodged debris. Ground cover includes scattered brush and grasses. No drainage improvements exist in the area.

$\bar{n} = 0.015$: Drainage area has fairly uniform, gentle slopes with most watercourses either improved or along paved streets. Ground cover consists of some grasses with appreciable areas developed to the extent that a large percentage of the area is impervious.

S-graphs.-- A summation hydrograph is a hydrograph of runoff that would result from the continuous generation of unit effective rainfall over an area. The ordinate is expressed as rate of runoff in percent of ultimate rate of runoff, and the abscissa is expressed in time units. An S-graph is a summation hydrograph modified to the extent that percent of ultimate discharge is plotted versus time in percent of lag.

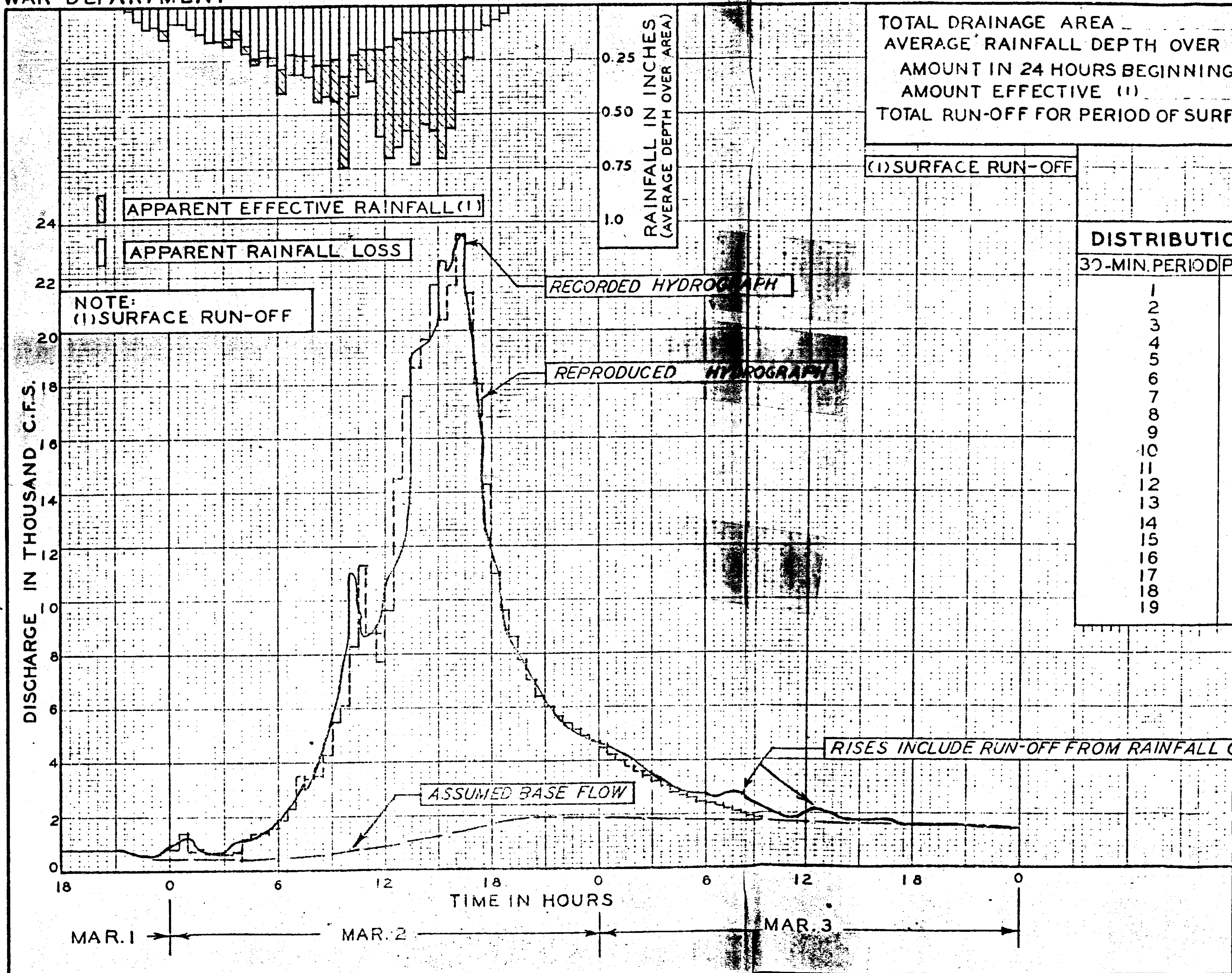
For unit hydrograph computation see sample computations.

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY

TOTAL DRAINAGE AREA .... 40.4 SQ. MI.
AVERAGE RAINFALL DEPTH OVER AREA:
AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 ..... 13.05 INCHES
AMOUNT EFFECTIVE (1) .... 6.70 INCHES
TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF ... {18,300 AC.-FT. / 8.50 INCHES}

(1) SURFACE RUN-OFF



DISTRIBUTION-GRAPH PERCENTAGES

30-MIN. PERIOD	PERCENT	30-MIN. PERIOD	PERCENT
1	1.7	20	1.0
2	10.3	21	0.9
3	31.0	22	0.9
4	10.0	23	0.8
5	6.5	24	0.7
6	5.3	25	0.6
7	4.2	26	0.5
8	3.7	27	0.5
9	3.2	28	0.4
10	2.7	29	0.4
11	2.0	30	0.4
12	1.7	31	0.3
13	1.6	32	0.3
14	1.5	33	0.3
15	1.4	34	0.2
16	1.3	35	0.2
17	1.2	36	0.1
18	1.1	37	0.1
19	1.0		

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
WHITTIER NARROWS F.-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

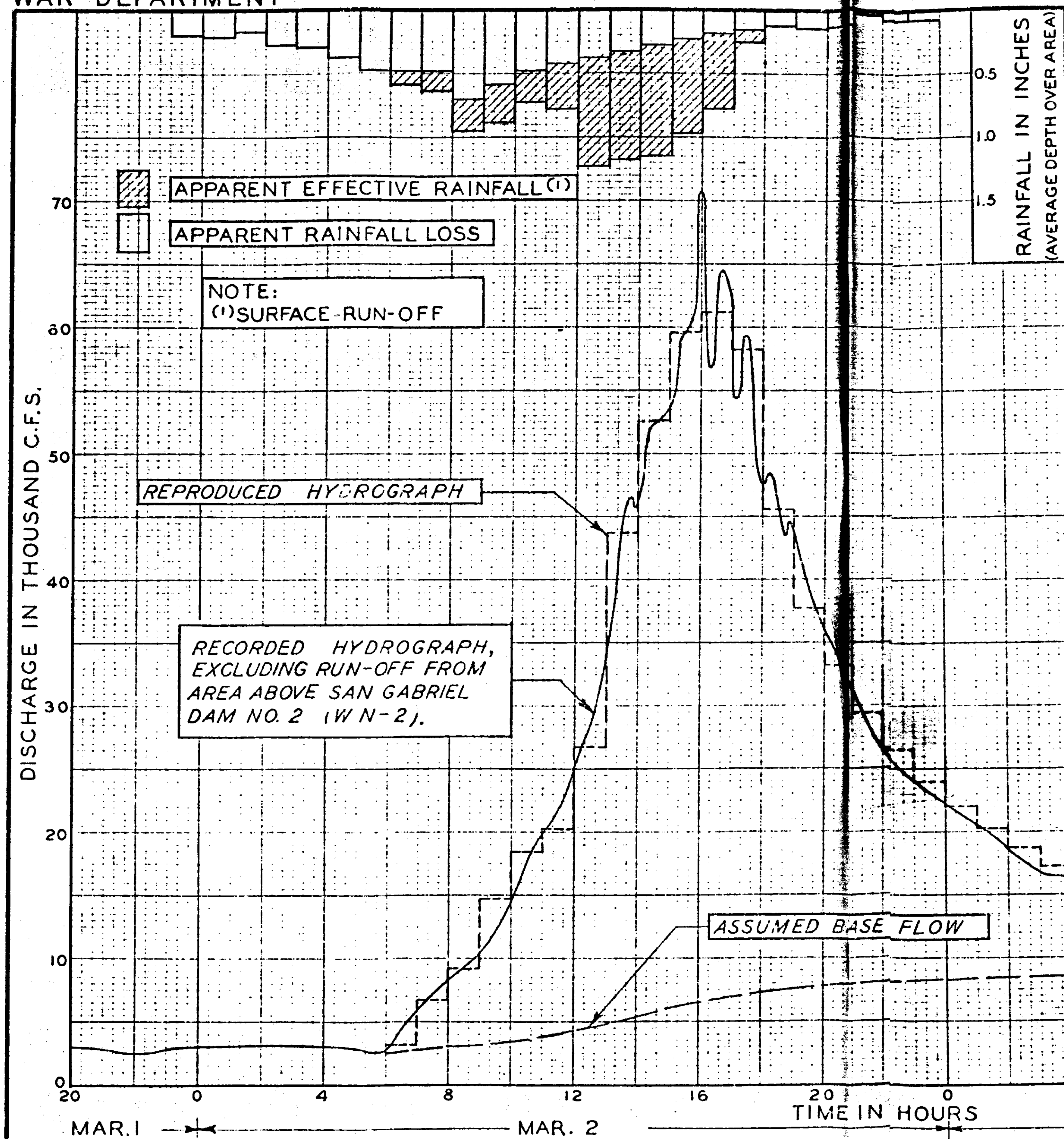
FLOOD OF MARCH 2, 1938
SAN GABRIEL DAM NO. 2

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44

FILE NO. 393/129

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



DISTRIBUTION-GRAPH PERCENTAGES

1-HR. PERIOD	PERCENT	1-HR. PERIOD	PERCENT	1-HR. PERIOD	PERCENT
1	4.0	10	3.2	20	0.8
2	26.7	11	2.9	21	0.7
3	12.1	12	2.5	22	0.6
4	8.5	13	1.9	23	0.5
5	7.1	14	1.7	24	0.5
6	6.2	15	1.5	25	0.4
7	5.2	16	1.3	26	0.3
8	4.2	17	1.2	27	0.2
9	3.5	18	1.1	28	0.1
		19	1.0	29	0.1

DRAINAGE AREA EXCLUDING DRAINAGE AREA ABOVE SAN GABRIEL DAM NO. 2 .... 161.6 SQ. MI.

AVERAGE RAINFALL DEPTH OVER AREA:

AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 .... 11.63 INCHES

AMOUNT EFFECTIVE (1) .... 5.40 INCHES

TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF { 69,500 AC.-FT. / 8.07 INCHES

(1) SURFACE RUN-OFF

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

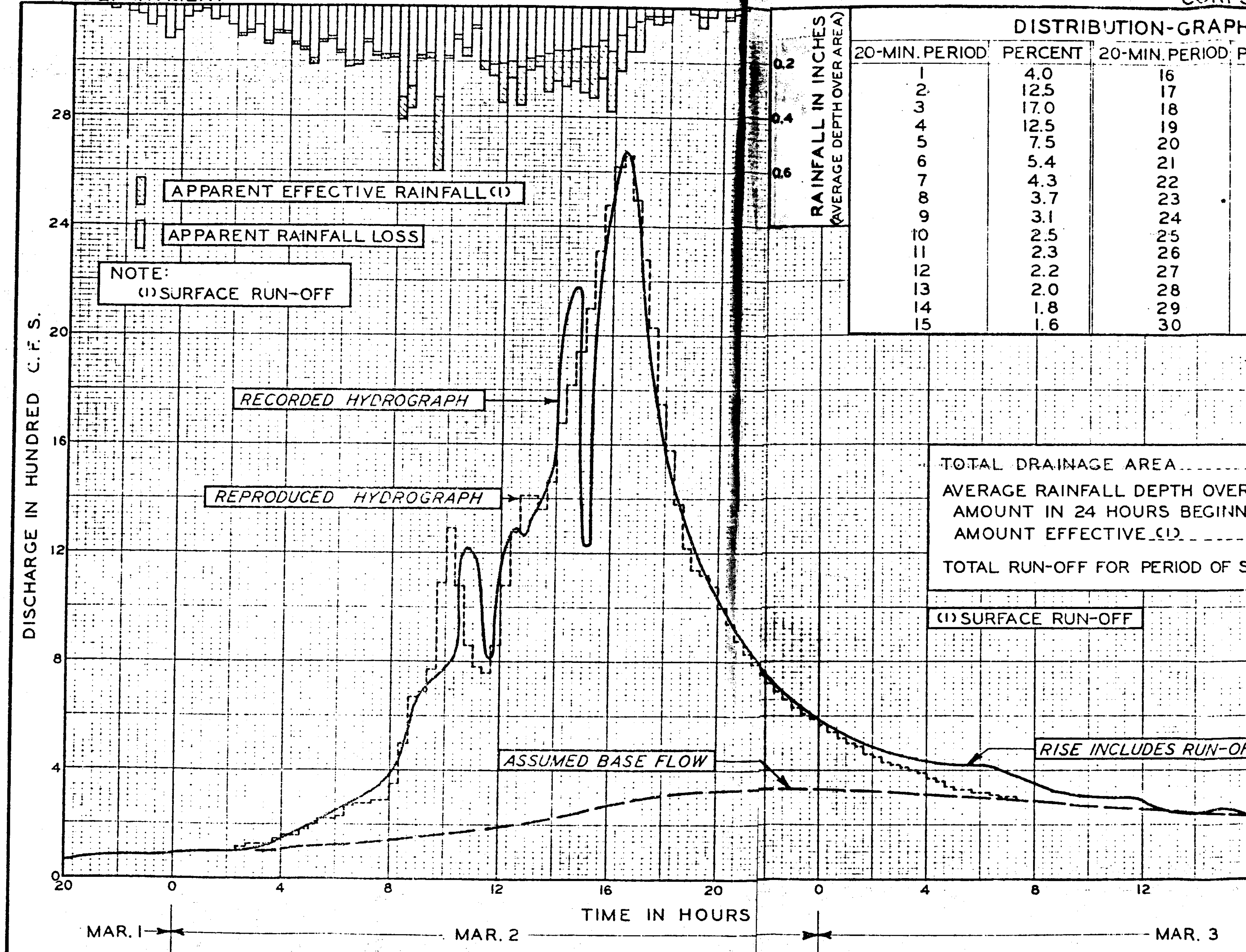
FLOOD OF MARCH 2, 1938
SAN GABRIEL DAM NO. 1

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44

FILE NO. 393/130

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



DISTRIBUTION-GRAPH PERCENTAGES

20-MIN. PERIOD	PERCENT	20-MIN. PERIOD	PERCENT	20-MIN. PERIOD	PERCENT
1	4.0	16	1.5	31	0.5
2	12.5	17	1.4	32	0.4
3	17.0	18	1.3	33	0.4
4	12.5	19	1.2	34	0.4
5	7.5	20	1.1	35	0.3
6	5.4	21	1.0	36	0.3
7	4.3	22	0.9	37	0.3
8	3.7	23	0.9	38	0.2
9	3.1	24	0.8	39	0.2
10	2.5	25	0.8	40	0.2
11	2.3	26	0.7	41	0.1
12	2.2	27	0.7	42	0.1
13	2.0	28	0.6	43	0.1
14	1.8	29	0.6	44	0.1
15	1.6	30	0.5		

TOTAL DRAINAGE AREA .... 9.5 SQ. MI.

AVERAGE RAINFALL DEPTH OVER AREA:

AMOUNT IN 24 HOURS BEGINNING 1700 MARCH 1 ... 10.43 INCHES

AMOUNT EFFECTIVE (1) .... 2.81 INCHES

TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF ... 2,000 AC.-FT. / 3.95 INCHES

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

FLOOD OF MARCH 2, 1938

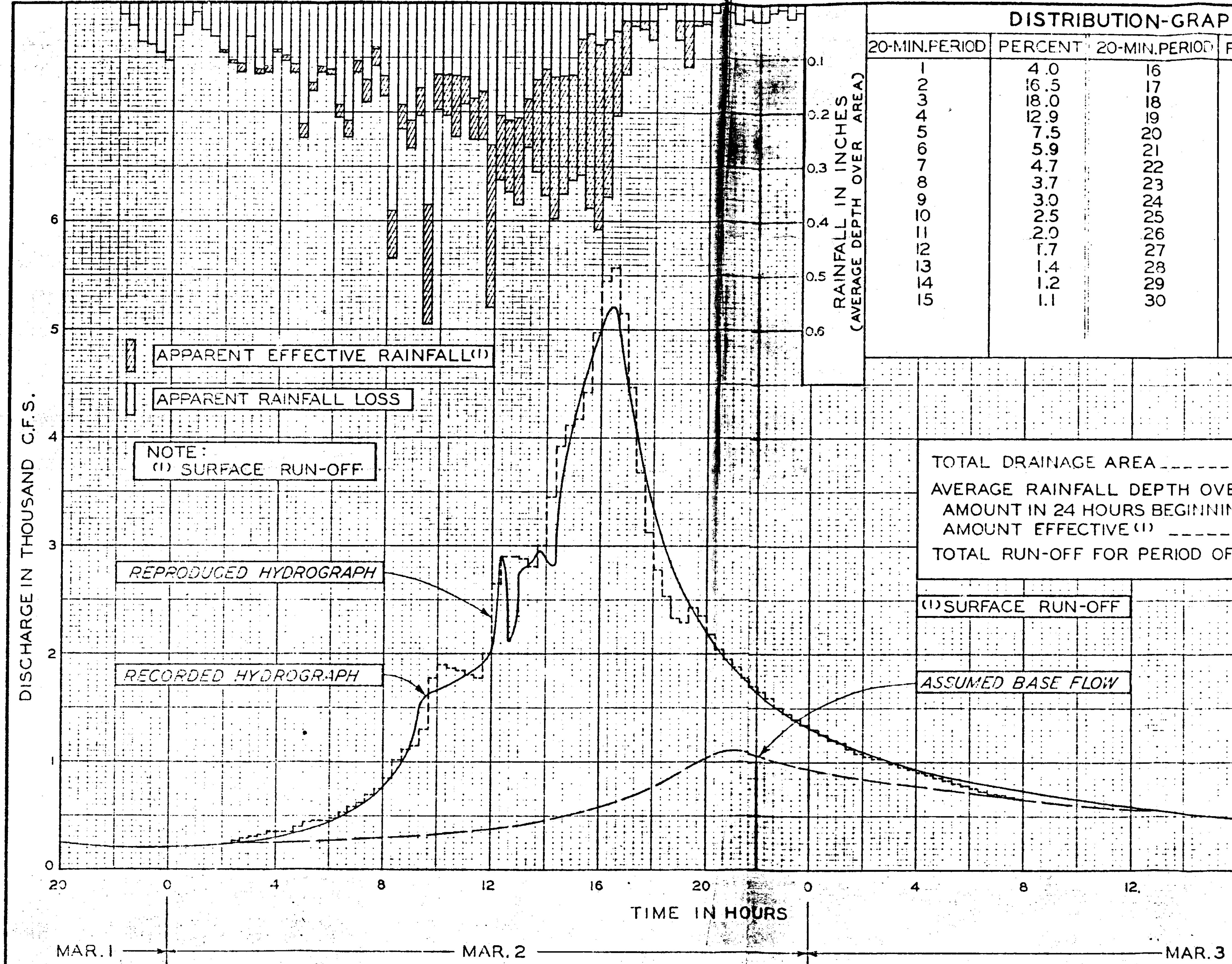
EATON WASH DAM

U. S. ENGINEER OFFICE

LOS ANGELES, CALIFORNIA

TO ACCOMPANY REPORT DATED: 12-20-'44

FILE NO. 393/131 PLATE 43



DISTRIBUTION-GRAPH PERCENTAGES

20-MIN. PERIOD	PERCENT	20-MIN. PERIOD	PERCENT	20-MIN. PERIOD	PERCENT
1	4.0	16	1.0	31	0.4
2	16.5	17	1.0	32	0.4
3	18.0	18	0.9	33	0.3
4	12.9	19	0.9	34	0.3
5	7.5	20	0.8	35	0.3
6	5.9	21	0.8	36	0.3
7	4.7	22	0.7	37	0.2
8	3.7	23	0.7	38	0.2
9	3.0	24	0.6	39	0.2
10	2.5	25	0.6	40	0.2
11	2.0	26	0.6	41	0.1
12	1.7	27	0.5	42	0.1
13	1.4	28	0.5	43	0.1
14	1.2	29	0.5	44	0.1
15	1.1	30	0.4	45	0.1
				46	0.1

TOTAL DRAINAGE AREA .... 10.8 SQ. MI.

AVERAGE RAINFALL DEPTH OVER AREA:

AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 .... 11.72 INCHES

AMOUNT EFFECTIVE (1) .... 4.65 INCHES

TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF { 4,250 AC.-FT. / 7.38 INCHES

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

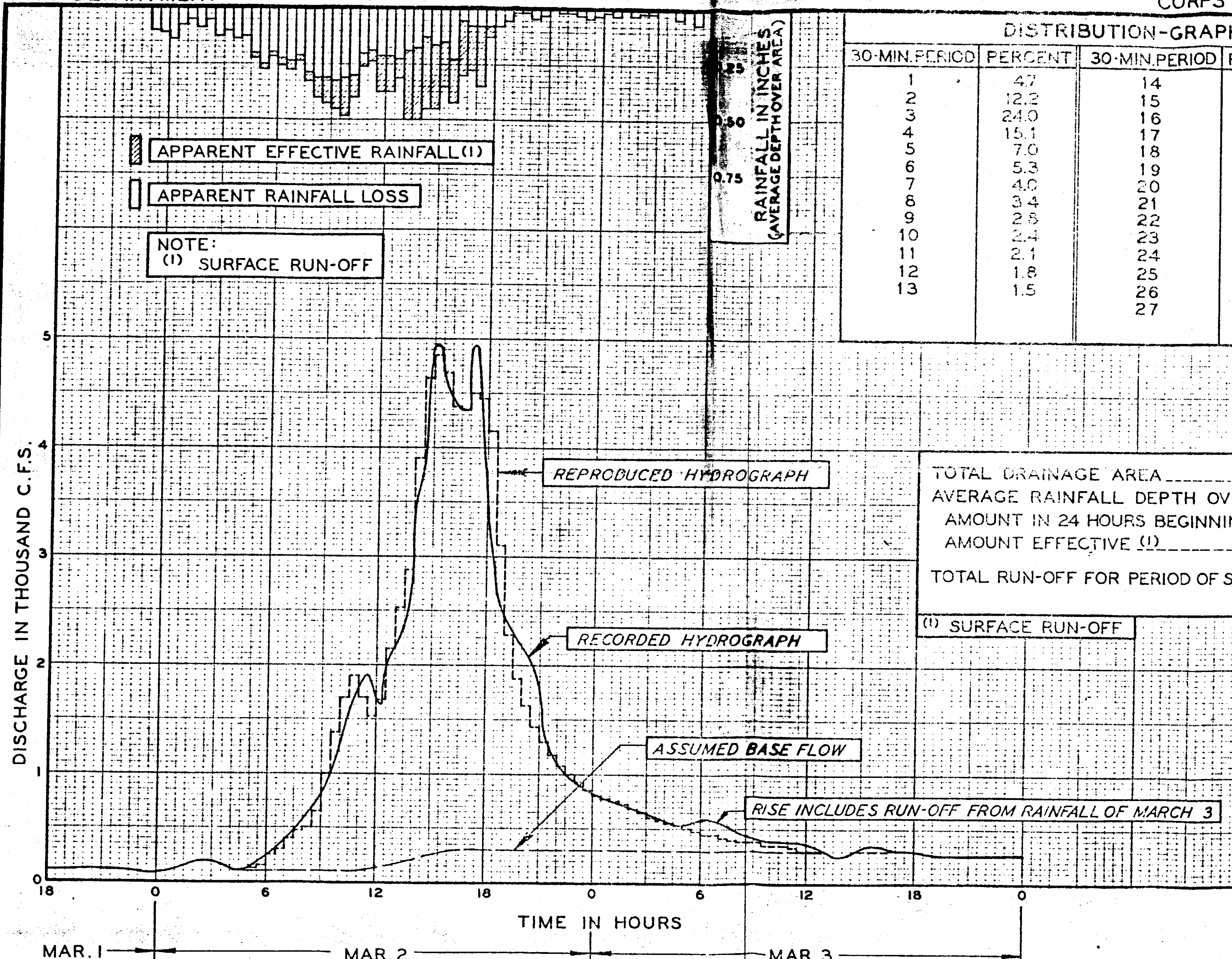
FLOOD OF MARCH 2, 1938

SANTA ANITA DAM

U.S. ENGINEER OFFICE

LOS ANGELES, CALIFORNIA

TO ACCOMPANY REPORT DATED: 12-20-'44



DISTRIBUTION-GRAPH PERCENTAGES

30-MIN. PERIOD	PERCENT	30-MIN. PERIOD	PERCENT	30-MIN. PERIOD	PERCENT
1	4.7	14	1.2	28	0.4
2	12.2	15	1.1	29	0.4
3	24.0	16	1.0	30	0.3
4	15.1	17	0.9	31	0.3
5	7.0	18	0.9	32	0.3
6	5.3	19	0.8	33	0.2
7	4.0	20	0.8	34	0.2
8	3.4	21	0.7	35	0.2
9	2.8	22	0.7	36	0.2
10	2.4	23	0.6	37	0.1
11	2.1	24	0.6	38	0.1
12	1.8	25	0.5	39	0.1
13	1.5	26	0.5	40	0.1
		27	0.4	41	0.1

TOTAL DRAINAGE AREA ________________ 16.2 SQ. MI.

AVERAGE RAINFALL DEPTH OVER AREA:

AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 ______ 9.97 INCHES

AMOUNT EFFECTIVE (1) ________________ 3.56 INCHES

TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF ___ { 3750 AC.-FT. / 4.34 INCHES

(1) SURFACE RUN-OFF

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTER NARROWS F.-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

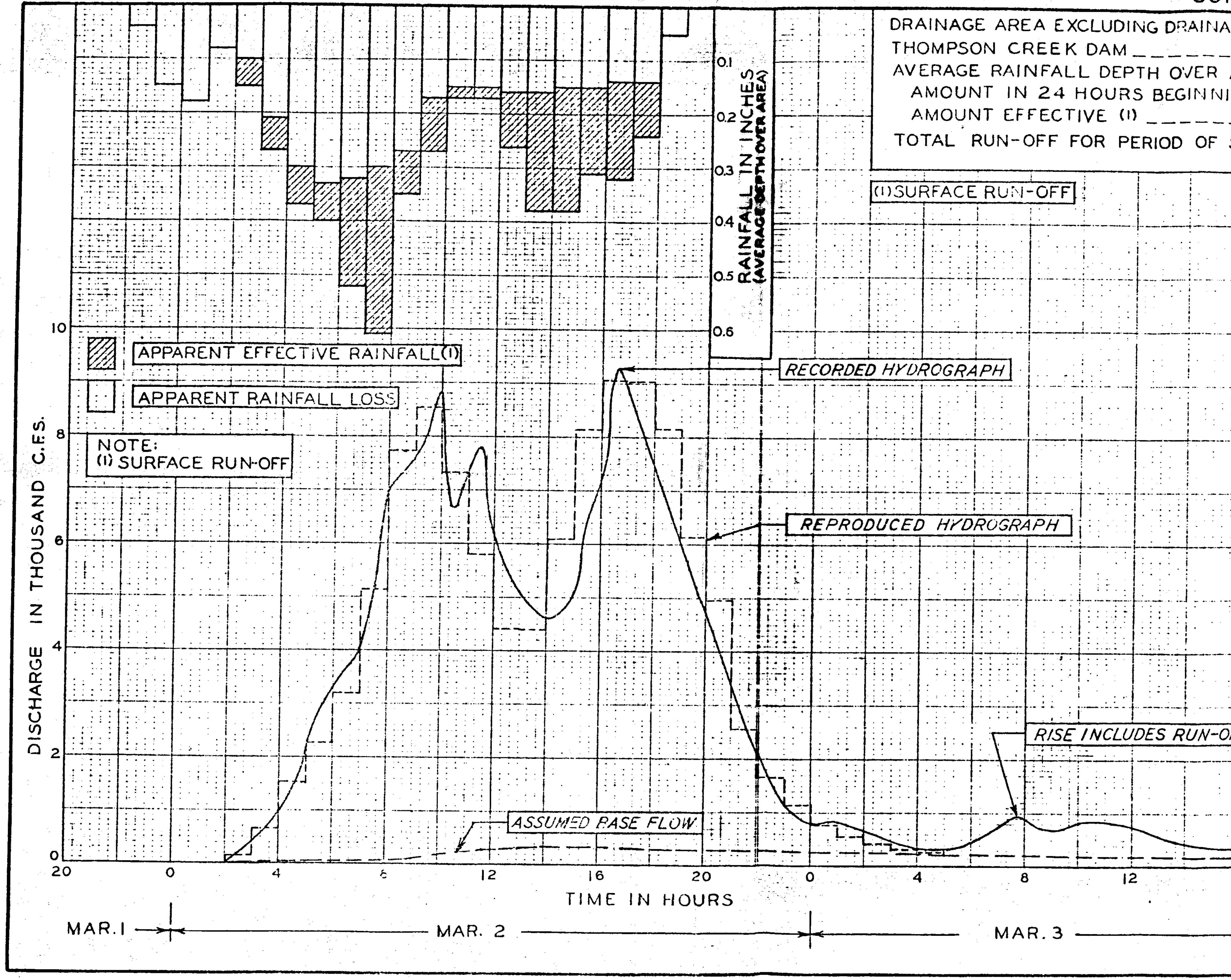
FLOOD OF MARCH 2, 1938

SAN DIMAS DAM

U. S. ENGINEER OFFICE

LOS ANGELES, CALIFORNIA

TO ACCOMPANY REPORT DATED: 12-20-'44



DISTRIBUTION-GRAPH PERCENTAGES

1-HR. PERIOD	PERCENT
1	5.0
2	19.0
3	27.0
4	19.0
5	12.0
6	7.5
7	4.2
8	2.5
9	1.8
10	1.1
11	0.6
12	0.3

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.-C. BASIN

DISTRIBUTION-GRAPH DETERMINATION

FLOOD OF MARCH 2, 1938

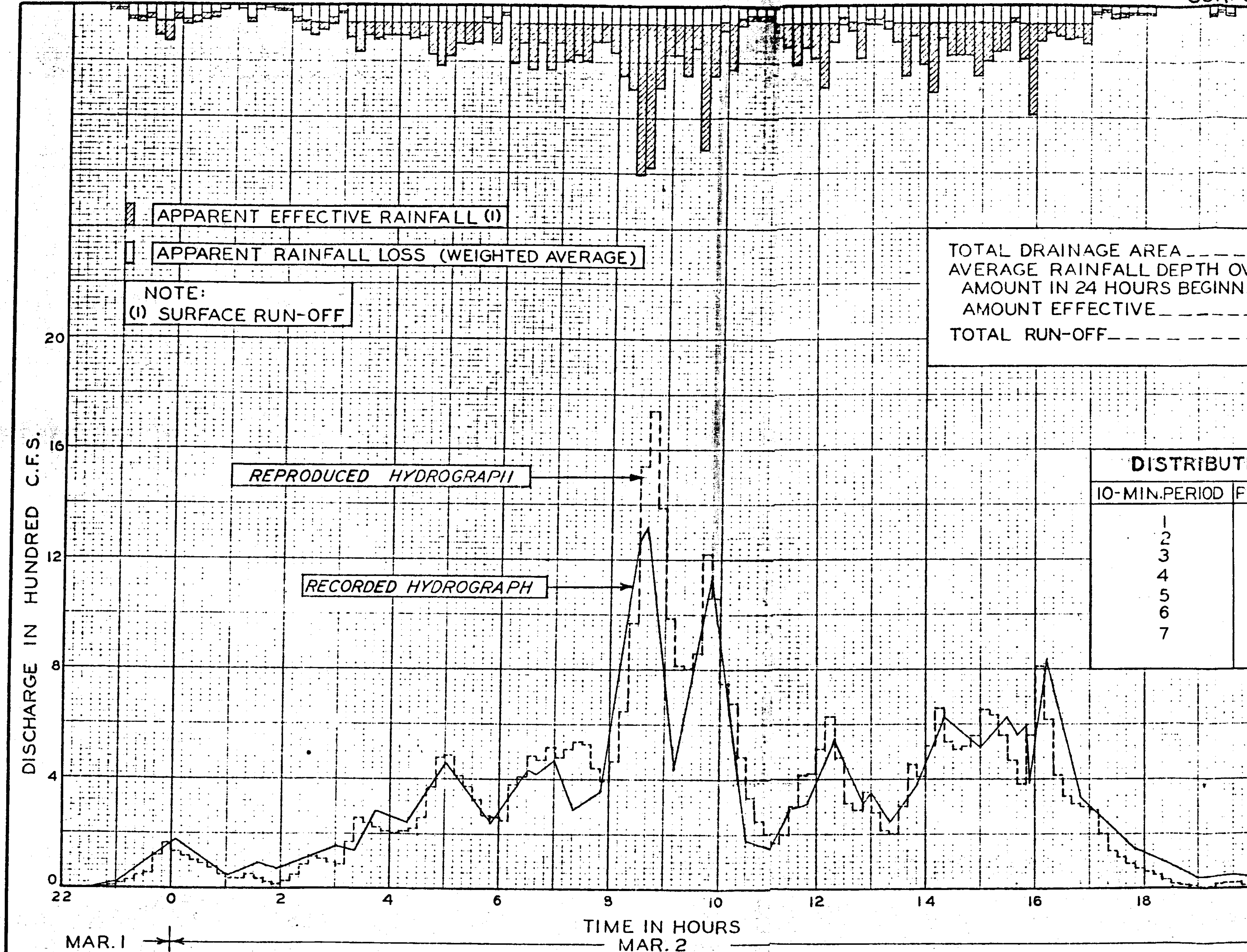
SAN JOSE CREEK

AT WORKMAN MILL ROAD

U.S. ENGINEER OFFICE

LOS ANGELES, CALIFORNIA

TO ACCOMPANY REPORT DATED: 12-20-44



TOTAL DRAINAGE AREA .... 2.5 SQ. MI.
AVERAGE RAINFALL DEPTH OVER AREA:
AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 .... 7.56 INCHES
AMOUNT EFFECTIVE .... 4.64 INCHES
TOTAL RUN-OFF .... 620 AC.-FT. / 4.64 INCHES

DISTRIBUTION-GRAPH PERCENTAGES

10-MIN. PERIOD	PERCENT	10-MIN. PERIOD	PERCENT
1	10.0	8	2.6
2	33.0	9	2.1
3	22.0	10	1.7
4	11.0	11	1.4
5	6.2	12	1.1
6	4.1	13	0.8
7	3.2	14	0.5
		15	0.3

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
WHITTIER NARROWS F.C. BASIN

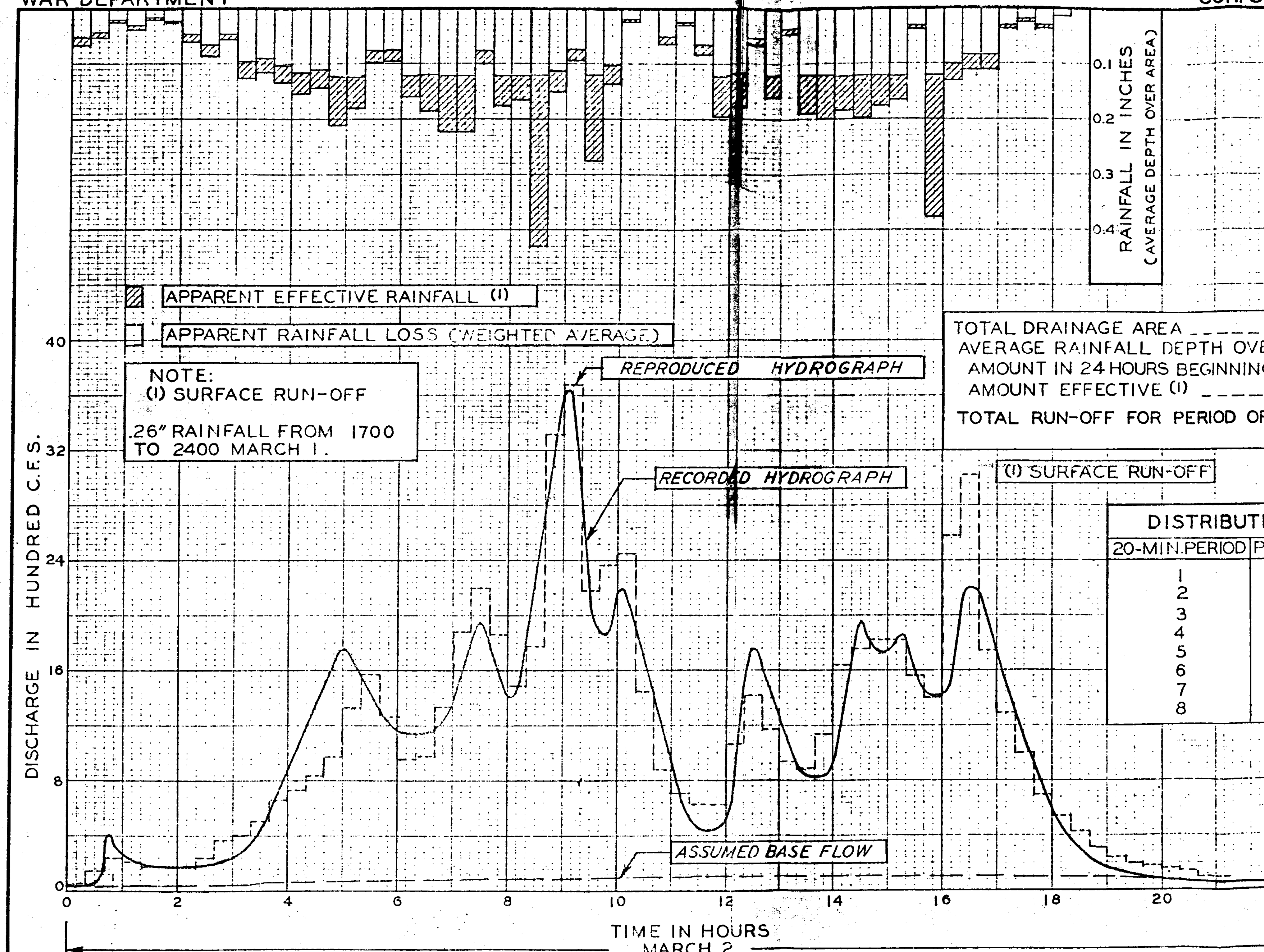
DISTRIBUTION-GRAPH DETERMINATION

FLOOD OF MARCH 2, 1938
BROADWAY DRAIN
ABOVE RAYMOND DIKE

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44

WAR DEPARTMENT

CORPS OF ENGINEERS, U.S. ARMY



NOTE:
(1) SURFACE RUN-OFF

.26" RAINFALL FROM 1700 TO 2400 MARCH 1.

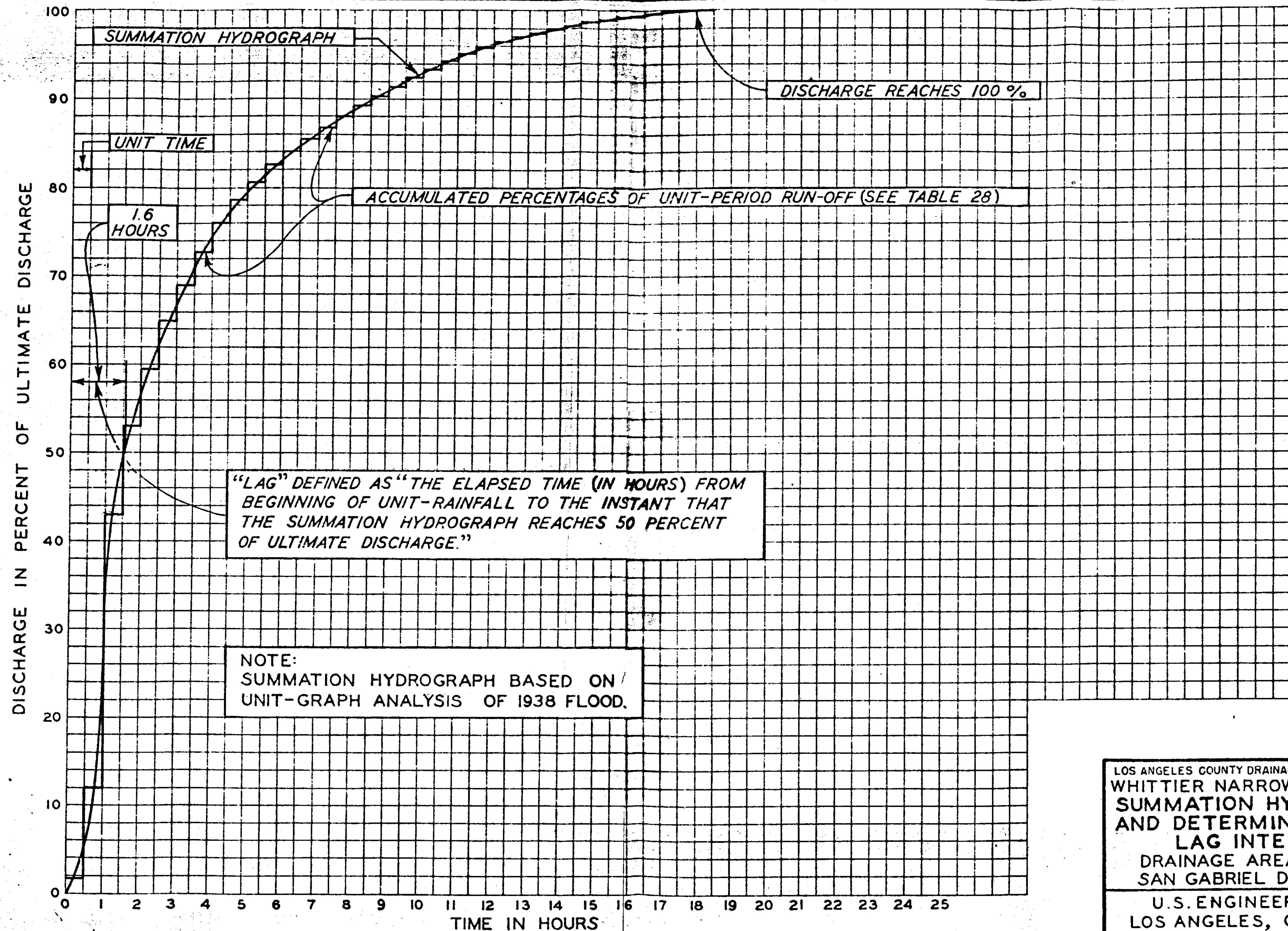
TOTAL DRAINAGE AREA .... 14.0 SQ. MI.
AVERAGE RAINFALL DEPTH OVER AREA:
AMOUNT IN 24 HOURS BEGINNING 1700 MAR. 1 .... 7.00 INCHES
AMOUNT EFFECTIVE (1) .... 2.38 INCHES
TOTAL RUN-OFF FOR PERIOD OF SURFACE RUN-OFF { 1,940 AC.-FT. / 2.60 INCHES

DISTRIBUTION-GRAPH PERCENTAGES

20-MIN. PERIOD	PERCENT	20-MIN. PERIOD	PERCENT
1	4.0	9	1.6
2	27.0	10	1.1
3	33.5	11	0.8
4	13.0	12	0.6
5	6.7	13	0.6
6	4.7	14	0.5
7	3.3	15	0.3
8	2.3		

LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
WHITTIER NARROWS F-C. BASIN
DISTRIBUTION-GRAPH DETERMINATION
FLOOD OF MARCH 2, 1938
ALHAMBRA WASH
ABOVE SHORT STREET

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-44



LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
WHITTIER NARROWS F-C. BASIN
SUMMATION HYDROGRAPH AND DETERMINATION OF LAG INTERVAL
DRAINAGE AREA ABOVE
SAN GABRIEL DAM NO. 2

U. S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-44

		DRAINAGE AREA SQ. MI.	L MILES	L_{CA} MILES	S FT./MI.	LAG HOURS
1	SAN GABRIEL RIVER AT SAN GABRIEL DAM NO. 1 *	161.6	23.2	11.6	350	3.3
2	WEST FORK SAN GABRIEL RIVER AT SAN GABRIEL DAM NO. 2	40.4	9.3	4.2	450	1.6
3	SANTA ANITA CREEK AT SANTA ANITA DAM	10.8	5.8	2.5	690	1.1
4	SAN DIMAS CREEK AT SAN DIMAS DAM	16.2	8.6	4.8	440	1.5
5	EATON WASH AT EATON WASH DAM	9.5	7.3	4.4	600	1.3
6	MURRIETA CREEK AT TEMECULA	220.0	27.2	10.3	95	4.0
7	SANTA CLARA RIVER NEAR SAUGUS	355.0	36.0	15.8	140	5.6
8	TEMECULA CREEK AT PAUBA CANYON * *	168.0	26.0	11.3	150	3.7
9	SANTA MARGARITA RIVER NEAR FALLBROOK	645.0	46.0	22.0	105	7.3
10	EAST FULLERTON CREEK AT FULLERTON DAM	3.1	3.2	1.7	140	0.8
11	TUJUNGA CREEK AT TUJUNGA DAM NO. 1	81.4	15.1	7.3	290	2.5
12	SANTA MARGARITA RIVER AT YSIDORA	740.0	61.2	34.3	85	9.5
13	SAN JOSE CREEK AT WORKMAN MILL ROAD * * *	81.3	23.7	9.1	75	2.4
14	ALHAMBRA WASH ABOVE SHORT STREET	14.0	9.5	4.6	85	0.6
15	BROADWAY DRAIN ABOVE RAYMOND DIKE	2.5	3.4	1.7	100	0.28

* EXCLUDES AREA ABOVE SAN GABRIEL DAM NO. 2

* * PALOMAR MOUNTAIN PORTION. ENTIRE AREA IS 319 SQUARE MILES, OF WHICH 151 SQUARE MILES DID NOT CONTRIBUTE APPRECIABLE FLOOD FLOWS DURING THE 1937 AND 1940 OCCURRENCES.

* * * EXCLUDING AREA ABOVE THOMPSON CREEK DAM.

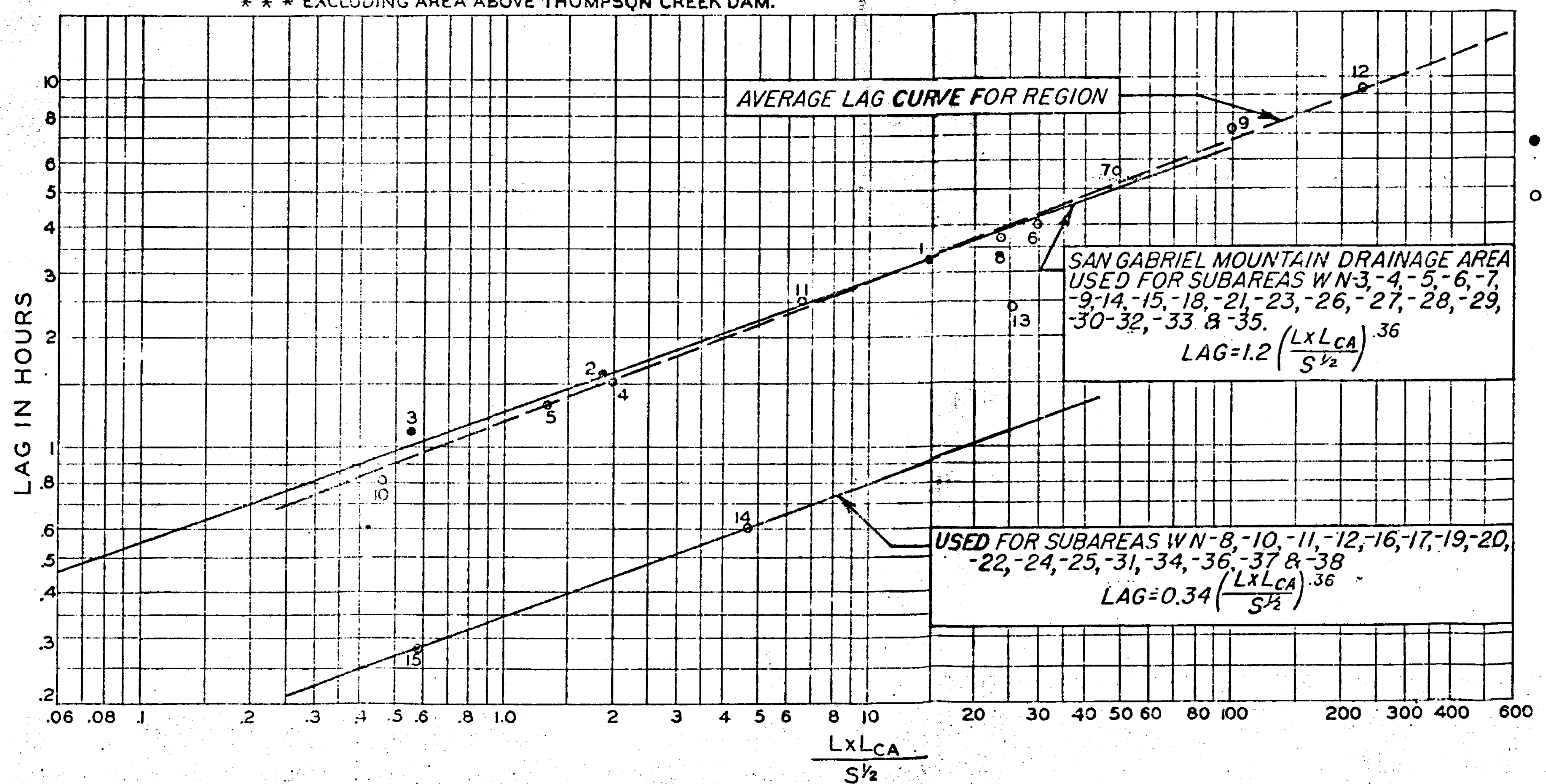
TERMINOLOGY

L = LENGTH OF LONGEST WATERCOURSE.

L_{CA} = LENGTH OF LONGEST WATERCOURSE, MEASURED UPSTREAM, TO POINT OPPOSITE CENTER OF AREA.

S = OVER-ALL SLOPE OF DRAINAGE AREA BETWEEN HEADWATERS AND COLLECTION POINT.

LAG = ELAPSED TIME FROM BEGINNING OF UNIT RAINFALL TO INSTANT THAT SUMMATION HYDROGRAPH REACHES 50 % OF ULTIMATE DISCHARGE.



LEGEND

● SAN GABRIEL RIVER AND STREAMS DRAINING THE MOUNTAIN FRONT.

○ OTHER REGIONAL STREAMS.

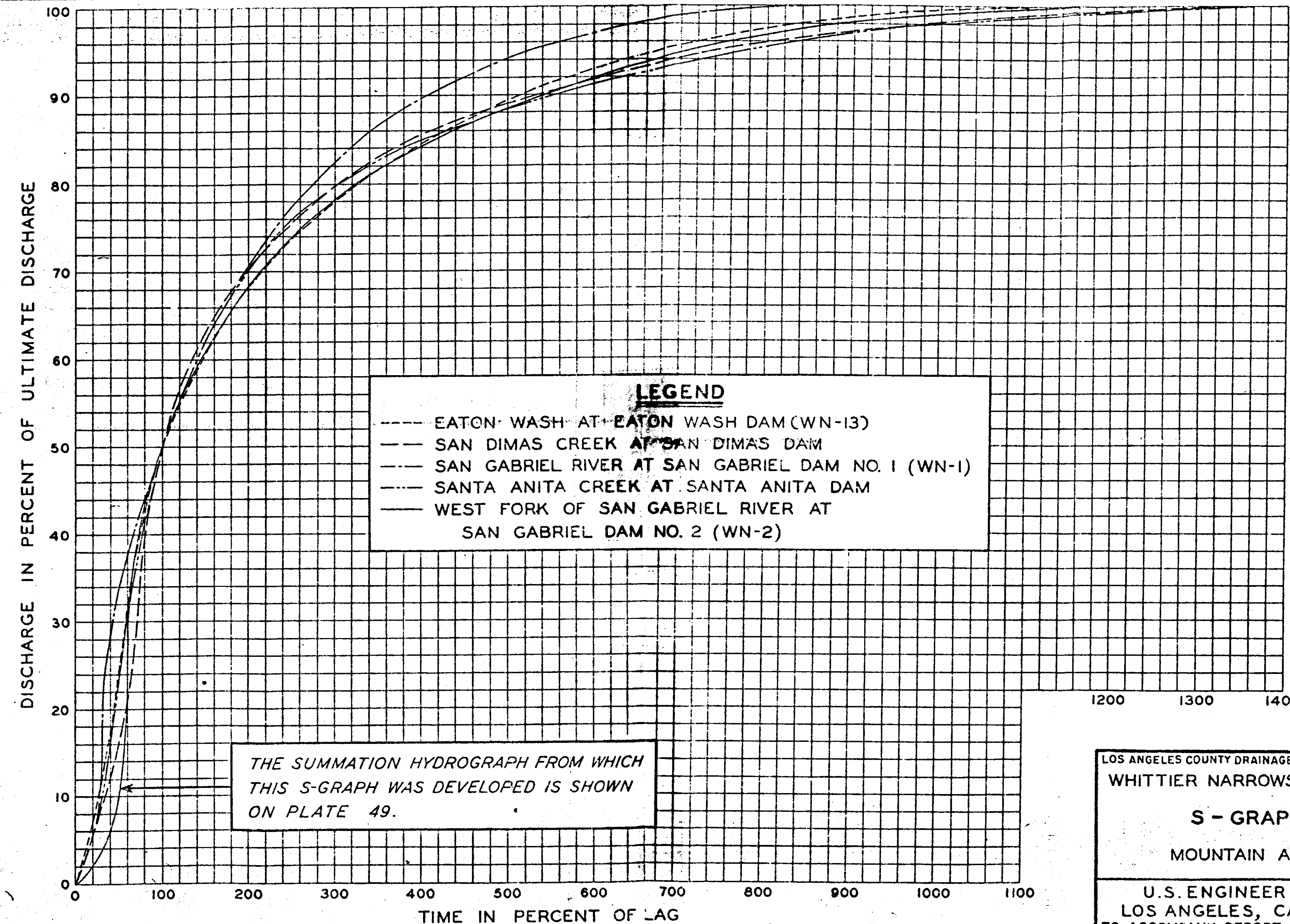
LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.C. BASIN

LAG RELATIONSHIPS

DRAINAGE AREAS IN SOUTHERN CALIFORNIA

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44



LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

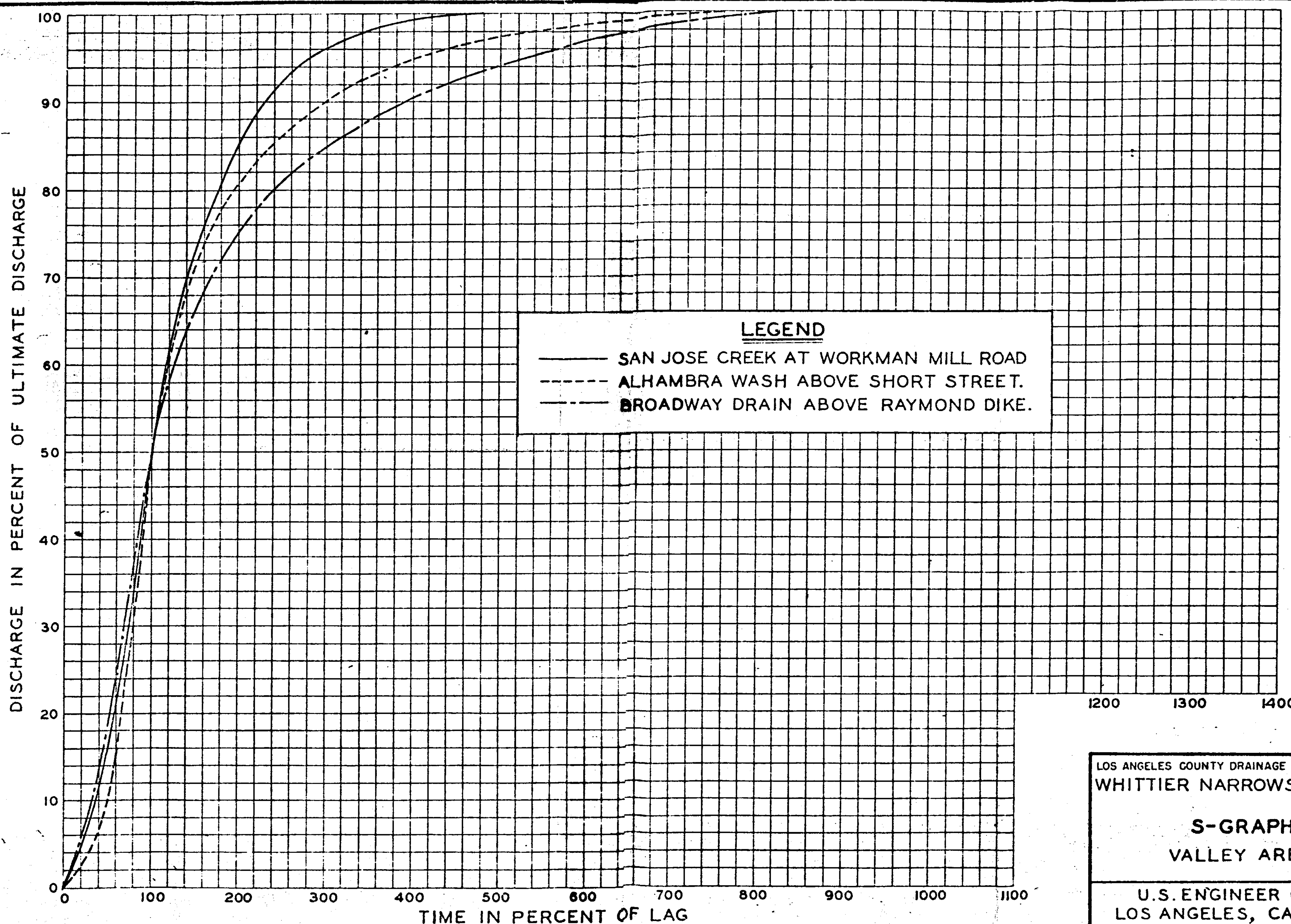
WHITTIER NARROWS F.-C. BASIN

S - GRAPHS

MOUNTAIN AREAS

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44

FILE NO. 393/139



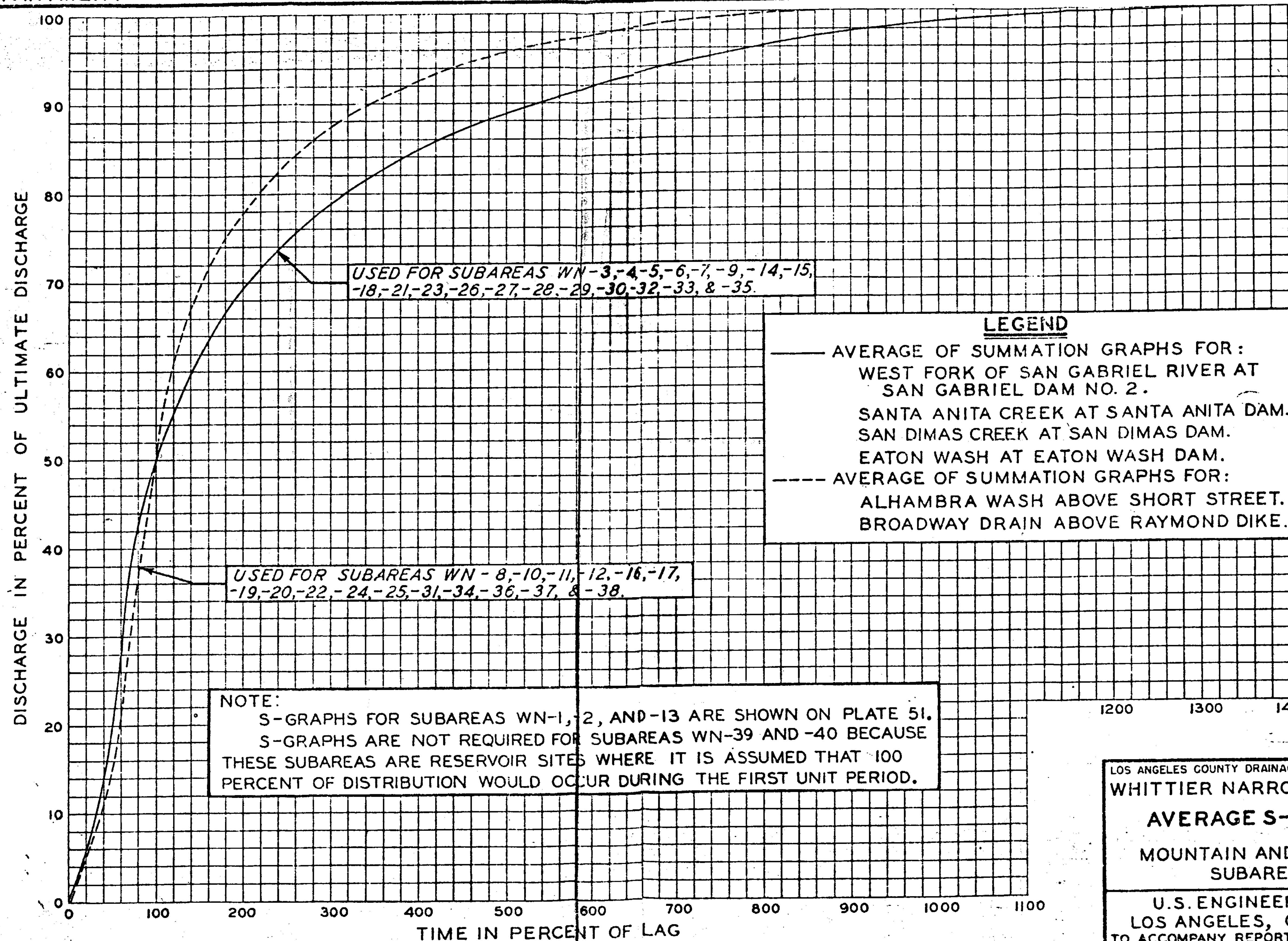
LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.-C. BASIN

S-GRAPHS

VALLEY AREAS

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44



LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA

WHITTIER NARROWS F.-C. BASIN

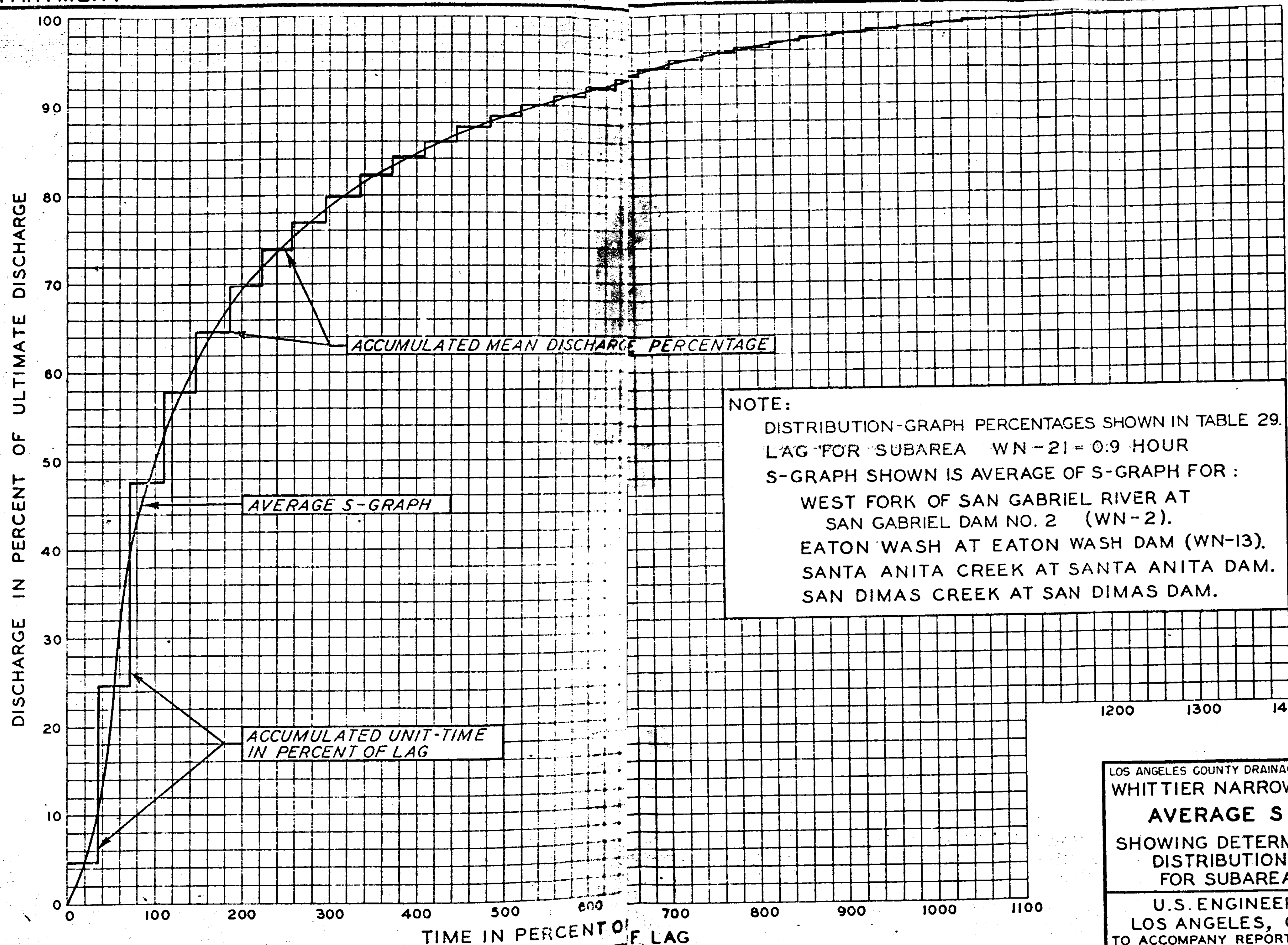
AVERAGE S-GRAPHS

MOUNTAIN AND VALLEY SUBAREAS

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-44

FILE NO. 393/141

WAR DEPARTMENT CORPS OF ENGINEERS, U. S. ARMY



LOS ANGELES COUNTY DRAINAGE AREA, CALIFORNIA
WHITTIER NARROWS F-C. BASIN

AVERAGE S-GRAPH

SHOWING DETERMINATION OF DISTRIBUTION GRAPH FOR SUBAREA WN-21

U.S. ENGINEER OFFICE
LOS ANGELES, CALIFORNIA
TO ACCOMPANY REPORT DATED: 12-20-'44

FILE NO. 393/142 PLATE 54

PAGE6.15 (12/16/02 0950)

PAGE6.15 (12/16/02 0944)

State of California - Department of Water Resources PAGE -6-
Division of Flood Management - California Cooperative Snow Surveys 1 of 4
Daily Snow Sensor Report
Snow Water Equivalents (inches) - December 15, 2002

Basin Name / Station Name	ID	Coop. Agency	Elev	Apr 1 Avg	Today	Percent Apr 1	24 Hrs Ago	1 Week Ago
TRINITY RIVER								
Peterson Flat	PET	DWR	7150	29.2	8.3	28%	6.5	5.0r
Red Rock Mountain	RRM	DWR	6700	39.6	13.3	33%	11.3	6.1
Bonanza King	BNK	DWR	6450	40.5	6.4	15%	5.0	1.8
Shimmy Lake	SHM	DWR	6400	40.3	14.2e	35%	12.2	5.6r
Middle Boulder 3	MB3	DWR	6200	28.3	5.5e	19%	3.2	1.3
Highland Lakes	HIG	DWR	6030	29.9	5.6	18%	5.3	0.0r
Scott Mountain	SCT	DWR	5900	16.0	4.9	30%	3.6	0.8
Mumbo Basin	MUM	DWR	5650	22.4	4.0	17%	2.8	0.0r
Big Flat	BFL	DWR	5100	15.8	2.4e	15%	1.8	0.0r
SACRAMENTO RIVER								
Cedar Pass	CDP	NRCS	7100	18.1	2.6	14%	2.6	2.1
Blacks Mountain	BLA	DWR	7050	12.7	---	---	---	---
Sand Flat	SDF	DWR	6750	42.4	10.7	25%	7.1	3.8r
Medicine Lake	MED	DWR	6700	32.6	6.6	20%	4.1	3.0e
Adin Mountain	ADM	NRCS	6200	13.6	3.3	24%	3.6r	3.4
Snow Mountain	SNM	DWR	5950	27.0	2.5e	9%	1.4	1.3
Slate Creek	SLT	DWR	5700	29.0	2.8	9%	2.8r	0.0r
Stouts Meadow	STM	DWR	5400	36.0	2.4	6%	1.2	0.0r
FEATHER RIVER								
Kettle Rock	KTL	DWR-BE	7300	25.5	4.8	18%	3.0	2.4r
Grizzly Ridge	GRZ	DWR-BE	6900	29.7	4.0	13%	2.4	1.7r
Pilot Peak	PLP	DWR-BE	6800	52.6	0.8	1%	1.0	0.0r
Gold Lake	GOL	DWR-BE	6750	36.5	9.2	25%	6.8	5.0
Humbug	HMB	DWR-BE	6500	28.0	9.6	34%	7.4	5.7r
Rattlesnake	RTL	DWR-BE	6100	14.0	1.7	12%	0.6	0.0r
Bucks Lake	BKL	DWR-BE	5750	44.7	0.2	0%	0.2	0.0r
Four Trees	FOR	DWR-BE	5150	20.0	0.7	3%	0.4	0.0r
EEL RIVER								
Noel Spring	NLS	USACE	5100	---	0.7	---	0.0	0.0r

State of California - Department of Water Resources PAGE -6-
Division of Flood Management - California Cooperative Snow Surveys 2 of 4
Daily Snow Sensor Report
Snow Water Equivalents (inches) - December 15, 2002

Basin Name Coop. Apr 1 Percent 24 Hrs 1 Week

Station Name	ID	Agency	Elev	Avg	Today	Apr 1	Ago	Ago
YUBA & AMERICAN RIVERS								
Lake Lois	LOS	DWR	8600	39.5	19.5r	49%	16.9	13.6r
Schneiders	SCN	SMUD	8750	34.5	13.1	37%	10.3	9.0
Caples Lake	CAP	DWR	8000	30.9	3.6	11%	1.9	1.8r
Alpha	ALP	SMUD	7600	35.9	3.0	8%	1.7	0.0r
Meadow Lake	MDW	DWR	7200	55.5	12.7	22%	10.9	8.5r
Silver Lake	SIL	DWR	7100	22.7	2.7	12%	1.2	0.0r
Central Sierra Snow Lab	CSL	NRCS	6900	33.6	5.7	16%	4.1	2.7r
Huysink	HYS	DWR	6600	42.6	4.4	10%	4.1	3.6r
Van Vleck	VVL	SMUD	6700	35.9	6.3	17%	5.5	2.3r
Robbs Saddle	RBB	SMUD	5900	21.4	2.0	9%	1.0	0.0r
Greek Store	GKS	DWR	5600	21.0	2.2	10%	1.3	0.0r
Blue Canyon	BLC	DWR	5280	9.0	2.5	28%	0.8	0.0r
Robbs Powerhouse	RBP	SMUD	5150	5.2	1.7	33%	0.4	0.0r
MOKELUMNE & STANISLAUS RIVERS								
Deadman Creek	DDM	DWR	9250	37.2	6.6	17%	5.7	5.1r
Highland Meadow	HHM	DWR	8700	47.9	12.4	25%	11.2	10.9
Gianelli Meadow	GNL	DWR	8400	55.5	8.0	14%	7.2	7.0r
Lower Relief Valley	REL	DWR	8100	41.2	10.3	24%	7.0	7.0
Blue Lakes	BLK	NRCS	8000	33.1	6.0	18%	4.0	3.2
Mud Lake	MDL	SMUD	7900	44.9	12.3	27%	10.1	6.2
Stanislaus Meadow	SLM	DWR	7750	47.5	8.0	16%	6.3	6.0r
Bloods Creek	BLD	DWR	7200	35.5	4.8	13%	2.4	1.4r
Black Springs	BLS	DWR	6500	32.0	2.9	9%	1.6	0.0r
TUOLUMNE & MERCED RIVERS								
Tioga Pass Entrance	TES	DWR/SS	9945	---	---	---	---	---
Dana Meadows	DAN	DWR	9800	27.7	9.4	34%	8.1	7.3r
Slide Canyon	SLI	DWR	9200	41.1	9.8	23%	9.2	7.9
Lake Tenaya	TNY	DWR	8150	33.1	8.6	26%	6.8	4.1e
Tuolumne Meadows	TUM	DWR	8600	22.6	6.1	27%	5.0	2.5e
Horse Meadow	HRS	DWR	8400	48.6	14.4	29%	11.8	7.2r
Ostrander Lake	STR	DWR	8200	34.8	8.5	24%	5.2	3.9
Paradise Meadow	PDS	DWR	7650	41.3	8.9	21%	7.0	4.4r
Gin Flat	GIN	DWR	7050	34.2	1.8	5%	0.6	0.0r
Lower Kibbie Ridge	KIB	DWR	6700	27.4	1.8	6%	0.7	0.0r
SAN JOAQUIN RIVER								
Volcanic Knob	VLC	DWR	10050	30.1	9.8	32%	9.2	8.5
Agnew Pass	AGP	DWR	9450	32.3	8.1	24%	7.4	6.1
Kaiser Point	KSP	DWR	9200	37.8	9.1	23%	8.8	9.1
Green Mountain	GRM	DWR	7900	30.8	2.0	6%	1.1	0.0r
Tamarack Summit	TMR	DWR	7550	30.5	1.2	3%	0.4	0.0r
Chilkoot Meadow	CHM	DWR	7150	38.0	1.3	3%	0.0	0.0r
Huntington Lake	HNT	DWR	7000	20.1	1.1	5%	0.0r	0.0r
Graveyard Meadow	GRV	DWR	6900	18.8	0.7	3%	0.1	0.0r
Poison Ridge	PSR	DWR	6900	28.9	0.8	2%	0.6	0.0r

State of California - Department of Water Resources PAGE -6-
Division of Flood Management - California Cooperative Snow Surveys 3 of 4
Daily Snow Sensor Report
Snow Water Equivalents (inches) - December 15, 2002

Basin Name / Station Name	ID	Coop. Agency	Elev	Apr 1 Avg	Today	Percent Apr 1	24 Hrs Ago	1 Week Ago
KINGS RIVER								
Bishop Pass	BSH	DWR/SS	11200	34.0	5.6	16%	5.0	4.3
Charlotte Lake	CRL	DWR/SS	10400	27.5	10.0	36%	9.2	9.1

State Lakes	STL	USACE	10300	29.0	6.8	23%	6.2	6.2r
Mitchell Meadow	MTM	USACE	9900	32.9	13.9	42%	13.5	13.4
Blackcap Basin	BCB	DWR/SS	10300	34.3	8.9	26%	7.9	7.6
Upper Burnt Corral	UBC	DWR/SS	9700	34.6	11.0	31%	9.7	9.1
West Woodchuck Meadow	WWC	USACE	9100	32.8	1.0	3%	0.5	0.0r
Big Meadows	BIM	DWR/SS	7600	25.9	4.0	15%	2.6r	0.0r
KAWEAH & TULE RIVERS								
Farewell Gap	FRW	DWR/SS	9500	34.5	8.0r	23%	7.5	7.5r
Quaking Aspen	QUA	DWR/SS	7200	21.0	1.2	5%	1.0	0.0r
Giant Forest	GNF	USACE	6650	10.0	0.4	4%	0.0	0.0r
KERN RIVER								
Upper Tyndall Creek	UTY	USACE	11400	27.7	5.4	19%	4.7	4.8
Crabtree Meadow	CBT	DWR/SS	10700	19.8	5.8	29%	5.5	5.4
Chagoopa Plateau	CHP	DWR/SS	10300	21.8	7.2	32%	7.2	7.2
Pascoes	PSC	USACE	9150	24.9	3.2	12%	2.3	2.5
Tunnel Guard Station	TUN	DWR/SS	8900	15.6	0.7	4%	0.0r	0.0r
Wet Meadows	WTM	USACE	8950	30.3	0.0	0%	0.0	0.0r
Casa Vieja Meadows	CSV	DWR/SS	8300	20.9	3.3e	15%	3.3e	3.3e
Beach Meadows	BCH	DWR/SS	7650	11.0	0.0r	0%	0.0r	0.0r
SURPRISE VALLEY AREA								
Dismal Swamp	DSS	NRCS	7050	29.2	3.8	13%	3.2	2.3
TRUCKEE RIVER								
Mount Rose Ski Area	MSK	NRCS	8900	38.5	13.3	34%	10.8	8.1
Independence Lake	IDP	NRCS	8450	41.4	12.8	30%	10.4	8.0
Big Meadows	BMW	NRCS	8700	25.7	5.8	22%	3.7	3.0
Squaw Valley	SQV	NRCS	8200	46.5	21.0e	45%	17.7	10.6
Independence Camp	IDC	NRCS	7000	21.8	2.2	10%	0.6	0.0r
Independence Creek	INN	NRCS	6500	12.7	2.7	21%	1.3	1.2r
Truckee 2	TK2	NRCS	6400	14.3	4.7	32%	3.1	2.1
LAKE TAHOE BASIN								
Heavenly Valley	HVN	NRCS	8800	28.1	6.6	23%	4.9	4.1r
Hagans Meadow	HGM	NRCS	8000	16.5	3.4	20%	1.6	1.0
Marlette Lake	MRL	NRCS	8000	21.1	3.9	18%	2.9	2.1
Echo Peak 5	EP5	NRCS	7800	39.5	11.1	28%	9.0	7.1r
Rubicon Peak 2	RP2	NRCS	7500	29.1	3.6	12%	2.1	1.4
Tahoe City Cross	TCC	NRCS	6750	16.0	2.0	12%	0.9	0.0r
Ward Creek 3	WC3	NRCS	6750	39.4	7.4	18%	5.2	4.0r
Fallen Leaf Lake	FLL	NRCS	6250	7.0	1.8	25%	0.3	0.0r

Daily Snow Sensor Report
Snow Water Equivalents (inches) - December 15, 2002

Basin Name / Station Name	ID	Coop. Agency	Elev	Apr 1 Avg	Today	Percent Apr 1	24 Hrs Ago	1 Week Ago
CARSON RIVER								
Ebbetts Pass	EBB	NRCS	8700	38.8	9.7	25%	7.8	6.3r
Poison Flat	PSN	NRCS	7900	16.2	5.3	32%	3.7	3.6r
Monitor Pass	MNT	NRCS	8350	---	5.0	---	3.5	3.1
Spratt Creek	SPT	NRCS	6150	4.5	1.7	37%	0.0r	0.0r
WALKER RIVER								
Leavitt Lake	LVT	NRCS	9600	---	15.8	---	12.1	10.3
Virginia Lakes	VRG	NRCS	9300	20.3	5.1	25%	4.2	4.1
Lobdell Lake	LBD	NRCS	9200	17.3	5.5	31%	3.8	3.7

Sonora Pass Bridge	SPS	NRCS	8750	26.0	4.2	16%	3.3	3.1
Leavitt Meadows	LVM	NRCS	7200	8.0	1.4	17%	0.0	0.0r
OWENS RIVER/MONO LAKE								
Gem Pass	GEM	DWR	10750	31.7	12.1	38%	9.4	9.4
Sawmill	SWM	DWR/SS	10200	19.4	8.2	42%	6.8	6.8
Cottonwood Lakes	CWD	DWR	10150	11.6	4.8	41%	4.8	5.1
Big Pine Creek	BGP	DWR	9800	17.9	5.8	32%	5.1	5.1
South Lake	SLK	DWR/SS	9600	16.0	4.9	30%	4.3	4.4
Mammoth Pass	MHP	DWR	9300	42.4	8.9	20%	7.6	7.6
Rock Creek Lakes	RCK	DWR	10000	14.0	3.5	25%	2.9	2.9

Values are inches of water, compared with 50-year averages.
Flags: (e) value is estimated (r) value revised from earlier report

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